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SCIENTIFIC MAN-POWER AND DEFENCE

THE developments of the past year have made the defence policy of Britain a matter of vital concern to the other partners in Western Union, and now to the United States of America. The broad issues of defence policy can no longer be determined in isolation. They must be intimately related to foreign policy, just as foreign policy in turn must be related to the effective resources of Britain for defence; our commitments must be precisely related to the man-power and equipment we can deploy. While these are matters of politics and not of science, scientific men are directly concerned with certain aspects of defence policy discussed in the recent White Paper on defence*, in the subsequent debates in Parliament and in the report of the Select Committee on Estimates dealing with the defence estimates†. A constructive approach to the problem of defence involves, besides public understanding, the close co-operation of many sections of the professions and of the industrial community. Besides, the issues of secrecy and of man-power, to both of which considerable attention has been directed, touch scientific workers very closely, quite apart from their interest as citizens in the general issues on which these questions were raised.

On the general issue of secrecy there was a complaint that insufficient information was laid before Parliament. In regard to research and development, the question of secrecy is a difficult one. The Minister of Defence emphasized in the House of Commons, as does the White Paper, that the Government regards progress in research and development as a matter of supreme importance, and expenditure on production now stands at £200 millions, or £50 millions more than in the previous year. Much of this money is spent in translating the results of research into experimental equipment, and particularly on new types of aircraft for the Royal Navy and the Royal Air Force. Mr. Alexander pointed out that some work is also supporting and encouraging engineering development of the highest type in industry, and instanced metallurgy and jet propulsion. The White Paper refers also to improvements in radar for the location of targets and for fire control; improvements in anti-aircraft fire control; and developments in equipment for the detection, location and destruction of submarines. Our knowledge about flight through the trans-sonic zone and at supersonic speeds has been extended, and the rate of fire of certain guns considerably increased. An important advance has also been made on the Bailey bridge. The Admiralty is, however, responsible for basic electronic research for all three Services.

It will readily be conceded, as the White Paper emphasizes, that for the most part progress in research and development must remain secret, especially where it is directed to the production of unconventional

* Statement on Defence, 1949. Cmd. 7631. (London : H.M. Stationery Office, 1949.) 4d. net.

† Second Report from the Select Committee on Estimates, Session 1948–49. H. of C. 86. (London: H.M. Stationery Office, 1949.) 4d. net.

weapons. Nevertheless, such secrecy involves certain problems of its own, and these should be considered before determining finally where the line between disclosure and secrecy should be drawn. The existence of secrecy may sometimes be a deterrent in recruitment to scientific posts, although it must be noted that secrecy restrictions in Great Britain involve no control of science or subscription to a scientific doctrine in which the scientific worker does not believe. Still more important, secrecy handicaps the public discussion which is so invaluable in securing the best deployment of our scientific and technical man-power, and in ensuring that the most profitable objectives are pursued.

The argument should not be pressed too hard, for even the secrecy requirements of war-time did not seriously impede co-operation of the type associated with what is known as operational research, and Mr. Alexander in his speech referred to the continuing development of this method. Nevertheless, the Select Committee on Estimates, in its second report for the session 1948–49, by way of comment on the omission from the Defence Budget or the Estimates since the War of details of expenditure on research and development, quotes at some length from a memorandum submitted by the Treasury to the Select Committee on Estimates of the session 1946–47. This memorandum states that the Treasury has considered with departments whether it would be possible to break up, under headings, the considerable expenditure incurred on research and development, but is satisfied that it would not be possible to do this without revealing information of importance. The Treasury suggests, however, that departments should provide the Select Committee and the Public Accounts Committee with confidential statements showing the important items in this expenditure, and the present Select Committee leaves the matter with the intimation that it intends to take an early opportunity of inquiring further.

On the man-power issue, a memorandum by the Permanent Secretary of the Ministry of Defence, appended to this report of the Select Committee, refers to the main task of the Defence Research Policy Committee as that of fitting the national research programme to the research facilities available; it says bluntly that there is not enough effort available for all the research and development tasks that the Services would like to see done. What is gradually being achieved is the optimum use of the effort that is available by allocating it in such a way as to ensure the maximum rate of progress on projects of the highest importance, so far as may be necessary, at the expense of projects of lesser importance. Mr. Alexander went further in speaking on this point on March 3. He wants to see the research staffs enlarged, and pointed out that in the last two or three years we had refrained from expanding the scientific services too much because of the prior claims of the universities, the teaching profession and industry. This year he hoped to make a long-needed increase.

That statement should be noted carefully. The correct distribution of scientific man-power in Great Britain is no simple problem, and while there is no real reason to be dissatisfied with the man-power policy pursued by the Defence Research Policy Committee or the Advisory Council on Scientific Policy under Sir Henry Tizard, fears were expressed at the annual luncheon of the Parliamentary and Scientific Committee that there was some danger of a serious shortage of scientific men in public departments. Whether such a break-away would appreciably affect the situation in industry is not clear; but Sir John Anderson thought that a review of the situation at this stage might be justified.

There is little doubt that Great Britain has set up an adequate organisation for the co-ordination of its scientific effort, though the distribution of that effort may well be affected and even distorted by conflicting and unco-ordinated policies elsewhere. Co-ordination over the whole field of public policy and expenditure is required; but before passing to consider that in conclusion, it might be noted that the Minister of Defence paid a tribute to the high quality of recruits to the scientific services. There was no evidence that the expansion of the universities had decreased the average quality of those graduating. Mr. Alexander further claimed that in no country was there a closer integration of military and scientific thought.

Doubts were freely expressed in the debates as to whether over the whole field of defence there was sufficient co-ordination and integration of the Services. The White Paper, it is true, refers once again to the establishment of specific machinery for inter-Service co-ordination in the administrative field, particularly for the medical, educational and chaplaincy services. It is, however, the effectiveness of the Ministry of Defence in providing a focal point for inter-Service consultation and for resolving those matters in which common administrative practice is desirable that is at present the real issue. The problems in the way of establishing a single high command are formidable, as the United States also has found; but in particular matters the weakness of the Ministry of Defence has become apparent. The Government has, for example, been singularly slow to realize how much the Ministry's failure to sift and co-ordinate the Services' demands for land for training areas has undermined confidence in its ability to handle other defence issues.

On this particular point, the Select Committee's report merely attempts to make clear how the framing of general policy to govern research and development and the correlation of production programmes are in practice effected, and the expenditure divided between the estimates for the various responsible departments. It is pointed out that both in the field of production and in that of research and development, responsibility for planning on one hand, and responsibility for detailed estimate, execution and accountancy on the other, do not rest with the same department, with the consequence that two departments instead of one are answerable for extravagance or inefficiency. The Committee appears to consider challenging the whole conception of a Ministry of Supply, however, and points out that in its present form the Defence Budget gives no clear picture of the research, develop-

ment and production work done for the Services by the Ministry of Supply. It is examining further the methods of organising works services adopted by the Ministry of Works to meet the requirements of the various departments.

The real questions, to which neither the White Paper nor the Defence debates give an adequate answer, relate not so much to the character of the defence organisation as to whether it is being wisely used, and whether it is directed to the right objectives. The crucial question is whether the army, air force and navy of Britain can make an immediate practical contribution to Western defence if required. The Minister of Defence failed completely to satisfy Parliament that he is framing a united, comprehensive system of defence and that our precious resources in men, money and materials in all three Services are being integrated and co-ordinated in the way that will best fit the country for the unified strategic action which modern warfare requires.

From these unsatisfactory debates, the importance of taking the question of defence out of the arena of party politics stands out clearly and is recognized on all sides. It is welcome news that there are to be private talks on defence between Government and Opposition leaders, with their colleagues. It is to be hoped that, as a result of those talks, agreed action in the interests of the country can be taken, not only about the direction and content of defence policy but also about the extent to which Parliament at least can be provided with information. No intrinsic excellence of scientific men and technologists will avail if their activities are not directed to the right objectives. Nor can we expect their zeal to be maintained at the level which is most fruitful unless they, along with their fellow citizens, are reasonably satisfied of the soundness of defence policy as a whole, and that every possible step has been taken to eliminate waste of money, man-power and material resources.

BRITISH PRACTICE IN CHEMICAL NOMENCLATURE

British Chemical Nomenclature

By Dr. A. D. Mitchell. Pp. viii+156. (London: Edward Arnold and Co., 1948.) 21*s.* net.

IN this volume Dr. A. D. Mitchell, for twenty-three years assistant editor of the *Journal of the Chemical Society*, sets out to do for British chemists what, since 1945, has been done for their American colleagues by the "Introduction" of *Chemical Abstracts*. Dr. Mitchell himself modestly describes his book as an attempt to expand into a monograph the lecture on "Modern Chemical Nomenclature" which Dr. Clarence Smith gave to the Chemical Society in 1936; but it may be doubted whether Dr. Smith could have done the task better than his colleague. Moreover, the book is no mere expansion of that lecture. Like the lecture, it deals with inorganic as well as organic nomenclature, and it derives its importance from the fact that it is an authoritative exposition of British practice. Hitherto this practice could only be ascertained laboriously and imperfectly from printed instructions to abstractors, which, until the issue by the Bureau of Chemical Abstracts in December last of its Brochure No. 4, "Principles of Abstracting", were several years out of date, and from footnotes, hidden, as Dr. Mitchell remarks, in the *Journal of the Chemical Society*.

Dr. Mitchell does not always cite chapter and verse for the practice he describes, and to that extent some of his statements may be *ex cathedra*. There is nothing pontifical, however, in his approach or treatment, and the book will derive much of its general appeal from the frankness with which inconsistencies or weaknesses in British practice are displayed. There is no attempt to gloss over or hide imperfections, and the merits of other systems of nomenclature are frankly recognized, even when, for expediency or other reasons, they are not adopted in British practice. Indeed, sometimes Dr. Mitchell does not stress, as he might have done, merits of British practice; for example, in the order of naming substituent groups, which constitutes one divergence between British and American practice, the British usage appears to have the merits of logic over the alphabetical system adopted by *Chemical Abstracts* as more economical of time.

Unlike Dr. W. Gaade's book "Beginselen der Organisch-Chemische Nomenclatur", also published last year, Dr. Mitchell's book is scarcely for the university student, but it should be of real value to chemists generally because of the attention he directs to such variations in British and American practice and to matters which might receive the attention of future international conferences. It is clear that British practice has moved considerably towards the adoption of the practices recommended in the Definitive Report of the Committee for the Reform of Nomenclature in Organic Chemistry of the International Union of Chemistry issued since Dr. Smith delivered his lecture, and that Dr. Mitchell himself leans strongly towards the adoption of the methods of the ring index of Dr. A. M. Patterson as providing a clear and logical system. On the question of trivial names he seems to take a less rigid view than *Chemical Abstracts* has done in recent years and to be content to keep the device within reasonable bounds.

It is in the clear grasp of general principles that Dr. Mitchell excels, and whatever may be the argument about the merits of particular details of practice that he may advocate, there are few organic chemists who could not well profit by greater attention to some of the general principles and points that he stresses. Outside the pages of the *Journal of the Chemical Society* there is too much nomenclature encountered which appears to be based on no more rational a recipe than "Take of British, American and International Rules according to taste, mix well, season with caprice, sprinkle with abbreviations, preferably ambiguous, and serve with the minimum legibility". Dr. Mitchell recognizes clearly the difficulties that are constituted by precedent, particularly in regard to ring systems and their enumeration; but he says, rightly, that the advantages to be gained from a comprehensive generalization far outweigh the few inconsistencies, some of which, at least, are due to deeply embedded practices in numbering, for example, the centre carbon atoms of the anthracene and acridine rings. The alternative is, indeed, increasing chaos.

It is, as Patterson says, a great aid to the memory to become accustomed to a fixed method of orient-

ation, and the careful but resolute application of such general principles as those of the international rules or the ring index would go further to remove the practical difficulties than is often admitted. Moreover, no small proportion of the residual difficulties where the principles lead to different enumerations and orientations for very similar substances lies in just that field where the question of oral communication becomes acute. The fact that names are intended to be spoken as well as read is commonly overlooked, and when a chemical name passes the limits when it can be conveniently used in spoken communication, there is little to be gained by translating structural formulæ into written names. Here the cipher may come into its own, just as in technology the chemist is driven to invent a code word or pet name, if a trade name is not available, in place of the correct chemical terminology.

This is one aspect at which Dr. Mitchell does not glance, though it has some bearing, as has just been indicated, on the adoption of international usage. None the less, his book should greatly encourage the use of more systematic nomenclature among British chemists and especially discourage the continuance of certain practices which lead to confusion; for example, the use of 'naphtha' as a prefix to denote a fusion of a naphthalene ring with a quinoline ring to give what should be described as a benzoquinoline, as well as the elimination of such redundancies as the use of the prefix 'mono-' in systematic names. For the help his book can give in such ways, apart altogether from its value in encouraging British and American collaboration in nomenclature, and the adoption of improved international usage, the book is well worth the price. To those who query the price of a guinea for so slender a volume, it might be observed that the formulæ are hand set, that the high standard of production and accuracy reflect great credit on author and publisher alike, and that the price should properly be compared with that which would be paid without question for another such working tool as a slide-rule, itself no more indispensable than the present volume. One minor point of criticism might be made in view of the probability of further editions being required. Something of a bibliography might well be included, such as that to be found in the "Introduction" to *Chemical Abstracts*, and in particular it would be well to specify where the 1947 report of the International Union of Chemistry Committee, cited on pages 2 and 62, can be found.

R. BRIGHTMAN

MATHEMATICAL THEORY OF SEMI-GROUPS

Functional Analysis and Semi-Groups

By Prof. Einar Hille. (American Mathematical Society: Colloquium Publications, Vol. 31.) Pp. xi+528. (New York: American Mathematical Society, 1948.) 7.50 dollars.

THIS work of Prof. Einar Hille is one of the important mathematical books of the century; it should be read seriously by every mathematician. The subject of semi-groups is one of great and growing importance, and the type of analysis on which its treatment is based—abstract spaces, linear operations, vector-valued functions, and general analysis in 'Banach algebras'—is scarcely less important.

The first five chapters of the book are headed, "Part One—Functional Analysis". Here Prof. Hille provides an excellent summary of topological concepts, the various types of abstract spaces to be employed, with special reference to Banach and Hausdorff spaces, strong and weak topologies; he gives (in outline, as not being the main object of the book) an account of linear transformations and functionals, abstract integration theories (chiefly the Bochner theory for the 'strong' form and the Pettis theory for the 'weak' form) and the development of the theory of vector-valued functions and of functions on vectors to vectors. Analysis in 'Banach algebras' (Prof. Hille's terminology) is then considered; these are what have usually been called 'normed rings' or 'normed vector rings', which, as Prof. Hille points out, is a misnomer from the algebraic point of view. They form outstandingly the most important example of a metric algebra, so that this chapter (5) is basic to the work; there is an excellent summary of spectral theory.

Chapters 6–15 are headed "Part Two—Analytical Theory of Semi-groups". In these chapters, Prof. Hille discusses subadditive functions, semi-groups, angular and topological semi-modules. In connexion with the latter, an interesting theorem—Zorn's category theorem—is published for the first time. There is much previously unpublished research included in the book; the debt which the subject owes to the author is apparent. We next have chapters on addition theorems in a Banach algebra, semi-groups in the strong topology, Laplace integrals and binomial series—for application to functions holomorphic in a half-plane, for example, the resolvent $R(\lambda; A)$ of the infinitesimal generator—generators and resolvents, generation of semi-groups (strongly continuous and uniformly continuous), analytical semi-groups, including analyticity in an angular semi-module and in a sector.

We now come to extremely interesting applications to ergodic theory and spectral theory (chapters 14, 15). Abelian and Tauberian theorems are given, for the Abel limit is connected, through the resolvent of the transformation, with the spectral properties of the operator. In the chapter on spectral theory, there is also a discussion of the degree of approximation of the identity (unit operator) by the semi-group operator for small values of the parameter, the results being of importance in the theory of summability and singular integrals. Prof. Hille remarks that this problem led him to his first investigations of semi-groups in 1935.

Chapters 16–21 are headed "Part Three—Special Semi-groups". These include translations and powers, trigonometric semi-groups, semi-groups in the Lebesgue space $L^p(-\infty, \infty)$, and in Hilbert space. Hilbert space is a specially important particular case of a Banach space, and the whole subject treated in this book owes a great deal to the early work of von Neumann and others on the axiomatic treatment of Hilbert space. The treatment in this space given by Prof. Hille is for *self-adjoint* semi-groups. It is interesting to note, in proof of the vital quality of semi-groups as a subject for research, that since Prof. Hille's book was written, two papers have been published by J. L. B. Cooper[1,2] giving a theory of one-parameter semi-groups of isometric operators in Hilbert space. Such a semi-group with suitable multiplicative properties leads to a *maximal* symmetric (Hermitian) operator as infinitesimal generator.

One of the most fruitful sources of one-parameter semi-groups is the theory of linear partial differential equations; this is the basis of chapter 20. In chapter 21, one-parameter semi-groups are applied to Abel summability, Hausdorff matrices, Markoff chains and probability matrices, Stochastic processes, and fractional integration. This chapter contains some highly interesting matter.

Finally, there is an appendix (chapter 22) on Banach algebras; here the emphasis is shifted from analysis to algebraic questions. There is an excellent bibliography.

The general presentation and style of the book is beyond praise. It is a book which is likely to promote copious research, and will be appreciated by mathematicians everywhere. R. G. COOKE

[1] *Proc. London Math. Soc.*, (2), **50**, 11 (1948).
[2] *Ann. Math.*, (2), **48**, 827 (1947).

FARM CROPS

Cultivated Plants of the Farm

By Dr. G. D. H. Bell. Pp. xii+199+36 plates. (Cambridge: At the University Press, 1948.) 15*s.* net.

THIS book on "Cultivated Plants of the Farm" breaks new ground both as regards its methods of treatment and the scope of its subject. Cultivated plants are not confined to any one area; but the same type is found over many parts of the world. The important point is that species and varieties vary, some being very widespread, and others more limited in scope. Cereals, such as wheat, barley and oats, have been in use for hundreds, even thousands, of years, and in one form or another are to be found all over the world. Others, such as potatoes and seed crops, are relatively younger and are in active process of being developed for use in various parts. Dr. G. D. H. Bell devotes a relatively small part of his book to a general survey of his subject, summarizing the main problems, dealing with the cultivation and economic conditions of crop plants, the present position of British crop husbandry, and the essential nature of crop rotation. After this the individual crops are dealt with separately, the wider scope of each being emphasized, though the greater part of the work deals with its relation to Britain.

Grassland in its various forms occupies a larger area of Britain than any other form of vegetation, and, owing to its ability to be used either as a short- or long-term crop, can fit in either as a rotation crop or as one which occupies the same ground for long periods of years. Its use as a rotation crop is one which is playing an increasingly important part in modern systems of agriculture. Wheat, barley and oats each play their separate parts in agriculture. Under present conditions it is more economic for Britain to import most of its wheat for milling, and to use much of its home-grown grain for feeding purposes. Barley has attained a great position owing to its suitability as a spring-sown corn, while oats fill in areas that are too wet for either of the other cereals. Leguminous plants, brassicas, potatoes, sugar beet and mangolds are the other chief crops grown in Great Britain, and each receives its meed of attention. As a finale, an outline is given of the position of seed stocks in Britain, with an indication of the improved varieties and strains that can now be produced by selection in existing stocks.

A final word of commendation must be given to Dr. Bell for his illustrations. These are presented in groups, each photograph being faced with a concise account of the crop to which the illustration refers, complete in itself, and giving a clear outline which obviates detailed reference to the text. Altogether, letterpress and illustrations alike combine in setting out a clear and concise account of present-day cultivated farm plants in Britain, and the way they are adapted to fit in with the national economy.

THE CASE AGAINST DARWINISM

Darwin, Before and After

The Story of Evolution. By Robert E. D. Clark. (Second Thoughts Library, No. 1.) Pp. 192. (London: Paternoster Press, 1948.) 6*s.*

THAT Darwin's particular hypothesis of natural selection operating upon small and random variations is incapable by itself of explaining the evolution of living organisms would be admitted even by Dr. Julian Huxley. That its widespread acceptance and exaggeration did grievous harm to the racial and political life of mankind is an easily arguable thesis. Dr. R. E. D. Clark in the present volume goes much further than either of these statements. He sets himself to denounce the whole concept of creative evolution—"every theory of evolution", he concludes (p. 145), "has failed in the light of modern discovery"—and to demonstrate not only that the evidence is against it but also that it conflicts with the principle of entropy or, as he calls it, "morpholysis", upon which "not merely physics but all science depends" (p. 150). In so doing he begins with the Greeks, has hard things to say about Cudworth and Spinoza, describes the conflict over preformation and epigenesis and the coming of belief in the fixity of species, and so arrives at the forerunners of Darwin. Then his study becomes more detailed. He makes much of Darwin's youthful vagaries, assigns to him psychological and religious conflicts, and treats his ill-health and his theory of evolution as the outcome of the sense of guilt. He describes somewhat confusedly the publication of the "Origin of Species" and the causes of its influence; and in a vigorous chapter entitled "Good Squib" makes it responsible for irreligion and 'big business', for racial oppression and the glorification of war, for Marx and Nietzsche, Hitler and Mussolini. Finally, he devotes two chapters to showing that evolution is contrary both to biological science and to physics, and a final one to qualifying much of what he has previously said by drawing a distinction between two uses of the word evolution, whereby he admits abundant evidence that "over long periods of time species undergo changes" but argues that this does not involve any ultimate increase in complexity.

If such a summary seems to bring out little that deserves attention, it is fair to add that Dr. Clark writes not only with vigour and conviction but also with real knowledge and often with justification. Many of his points are soundly and shrewdly argued; many of his criticisms are justifiable. Unfortunately, he overstates his arguments so much as to produce manifest inconsistencies—compare the condemnation of 'preformation' on p. 144 with the praise of it on pp. 26 and 183, or the insistence upon disorder on p. 151 with that upon order on p. 153.

As the book is written from a religious point of view, it may be well to add two, more theological, criticisms: Dr. Clark nowhere seems to realize that creation, if "the ever-working God" and not "a master-magician" is the Creator, must be a process and not an act and that the study of evolution is the study of that process; nor does he explain how if, as he perpetually insists, the universe is subject to a law of disorder, it can be the creation of a God who is both orderly and loving. C. E. RAVEN

BEGINNINGS OF DEVELOPMENT IN THE EMBRYO

Recherches sur le déterminisme de la symétrie bilatérale dans l'œuf des amphibiens

Par Prof. P. Ancel et P. Vintemberger. (Bulletin biologique de France et de Belgique, Supplément 31.) Pp. iii+182+4 plates. (Paris: Laboratoire d'évolution des êtres organisés, 1948.) n.p.

THE determination of the plane of bilateral symmetry is one of the most important events in embryonic development, since it sets the framework of that essential cytoplasmic heterogeneity which alone makes it possible for one and the same genotype to control the differentiation of many types of tissue. In some eggs (of which insects provide clear-cut examples), the bilateral structure is built into the ovum during its maturation within the ovary. In others, among them apparently all vertebrate ova, bilaterality does not become visible until after fertilization, and much research has naturally been directed to discovering the factors to which it is due. The Amphibia have, here as in so much of experimental embryology, provided the most favourable material for study. A long series of observations and experiments on this group by Prof. P. Ancel and P. Vintemberger, which have now been brought together in book form, seems to go far towards providing at least an interim conclusion, which may last some time before it is superseded.

The main technical innovation which the authors have made is the use of small localized electrolytic marks on the egg cortex. By the observation of the movements of such marks, they have shown that the appearance of a visibly bilateral structure (signalized by the formation of a 'grey crescent') is always preceded by a rotation of the cortex, particularly of the upper pigmented region, around a horizontal axis. This so-called 'rotation of fecundation' is so directed that the side towards which the pigmented cap moves becomes the ventral side. The axis of the rotation, and its direction, is affected not by one but by a series of pre-conditioning factors, the most important of which are the position of entry of the spermatozoon, the inclination of the egg if any, the direction of the 'rotation of orientation' which occurs soon after fertilization, and the compression of the egg. These co-operate to produce a preliminary concentration of pigmented cortex on the ventral side, which becomes accentuated when the 'rotation of fecundation' occurs.

Such a point of view clears up many of the divergences of opinion which have been a feature of the previous literature on the subject, and the two authors are able to support it with the evidence of a large body of new relevant experiments.

C. H. WADDINGTON

A TEXT-BOOK OF FERMENTATION

Micro-Organisms and Fermentation

By the late Alfred Jørgensen. Rewritten by Albert Hansen. Pp. 551+37 plates. (London: Charles Griffin and Co., Ltd., 1948.) 60*s*. net.

IN preparing a new fifteenth edition in English of the late Alfred Jørgensen's famous text-book on fermentology, the present director of Jørgensen's Laboratory in Copenhagen chose wisely to rewrite the work. By so doing, new facts have been incorporated, and the work, viewed as a whole, reflects modern ideas. However, the plan of the book is still that of Jørgensen and follows that of the 1939 edition with only minor changes.

The early chapters are devoted to general microbiology. The chapters are of exceptional value in that they meet a specific need of the fermentologist, namely, a groundwork of the subject written from his own particular point of view. The main substance of the book is dealt with in three succeeding chapters devoted respectively to moulds, yeasts and yeast-like organisms, and bacteria. Each of these groups is discussed in general, and detailed descriptions are given of individual species, studied both as species and from the point of view of their technological importance. The chapter on the yeasts has been brought up to date with an account of yeast genetics, as elucidated by Winge and also by Lindegren. Consideration is given to both top and bottom varieties of brewer's yeasts, to wine yeasts, wild yeasts and yeast-like fungi. An important section is devoted to the practical employment of yeasts in the brewing, wine and pressed-yeast industries.

Of the bacteria, the acetic and lactic acid organisms are treated in considerable detail, both in relation to their industrial use and also in their capacity as undesirable contaminants. It is to be noted that, in referring to the lactic acid bacteria, Orla-Jensen's nomenclature is used, rather than that given in Bergey's "Manual". Shorter sections are devoted to the propionic acid bacteria, *Micrococcus* and *Sarcina*, the *coli-aerogenes* group, the aerobic putrefiers and the spore-formers, in so far as these organisms interest the fermentologist. A new section on tobacco fermentation has been added. This chapter is of no less value to the microbiologist dealing with dairy products than it is to the brewer of beer, wine or vinegar.

This volume was ". . . prepared with a special view to the teaching of Fermentology and technical Bacteriology at the Alfred Jørgensen Laboratory . . .", so that British fermentologists interested in top fermentation brewing may find an emphasis on the bottom-fermentation process. Perhaps, also, more consideration of the work of J. L. Shimwell on the systematization of the bacteriology of brewing would have been welcomed from similar quarters. One omission of a different nature is also noticeable, namely, that no space is given to the large-scale production of antibiotics by moulds.

These criticisms can, however, detract but little from the merit of this unique text-book, which will be indispensable to the student and teacher of fermentology, to the microbiologist in industry, to the mycologist and general bacteriologist alike. A final word of praise is due in recognition of the high quality of book production manifest in this volume, which is excellently printed on good paper and handsomely bound. C. RAINBOW

General and Applied Chemistry

A Brief College Course. By Prof. Arnold J. Currier and Prof. Arthur Rose. (International Chemical Series.) Pp. ix+275. (New York and London: McGraw-Hill Book Co., Inc., 1948.) 18*s*.

THIS book affords a one-year course in chemistry for students whose main subject is agriculture, engineering or other applied science. Its aim is to help the study of these subjects by giving a knowledge of materials. Obviously such a course must cover much of the usual ground of introductory chemistry. Actually the subject-matter is approximately the chemistry required for matriculation, with the addition of two chapters on carbon compounds. Questions and exercises are within, and reading references at the end of, each chapter. There are an appendix of useful tables and an index. Theory is not unduly stressed, the main emphasis being on the everyday application of materials. This feature is thoroughly well done. The only notable omissions are some account (rather than a mention) of adsorption and the colloidal state, and some discussion of the handling of materials and of the hazard of their indiscriminate mixing.

Its numbered paragraphs, its interesting tables, its clear and simple exposition of principles and concepts, make this book most suitable for the class of students for whom it was written. G. F.

General Chemistry for Colleges

By Alexander Smith. Sixth edition, by Prof. William F. Ehret. Pp. xiii+677. (New York: D. Appleton-Century Co., Inc.; London: G. Bell and Sons, Ltd., 1946.) 20*s*. net.

FIRST published in 1906, hitherto kept up to date by Prof. Kendall, this book, embodying Smith's distinctive presentation of the subject, has profoundly influenced the teaching of chemistry. The present editor is to be congratulated on retaining the solid framework of the original "Smith", while making what is practically a new book. The size of the page has been increased so that it now measures 9½ in. × 6½ in., permitting of the use of large and striking illustrations; and Prof. W. F. Ehret has revised and added to the reading references, and has thoroughly overhauled the sets of questions. However, his greatest innovation is his treatment of the theoretical matter, most of which he has rewritten. Atomic architecture now occurs earlier in the book, so that structure can be related to properties. Indeed, all the newer physical concepts which throw such light on structure and behaviour are clearly and simply expounded. Terms not yet in general use, such as 'oxidation numbers', and Brönsted's definition of acids, are explained and temperately discussed. This revision, so thoroughly and ably done, will ensure "Alexander Smith" retaining its place in the first class of chemistry texts. G. F.

Worked Examples in Chemistry

By H. P. Starck. Pp. 176. (London: Hutchinson's Scientific and Technical Publications, n.d.) 12*s*. 6*d*. net.

THE 156 worked examples which make this book are mostly taken from recent papers set at Inter-Science, First M.B., National Certificate, Higher Schools and similar examinations. The problems are not limited to elementary work and to the calculations of analysis, but illustrate a variety of subjects such as the partition coefficient, the eutectic point, osmotic pressure and related phenomena, electrolysis and electrode potentials. The author has classified the examples, grouped them into chapters of increasing difficulty, and whenever necessary added theoretical matter to make clearer an understanding of the principles involved. Much experience in a technical college has thoroughly acquainted him with the difficulties of students, so we find these illustrative examples clearly set out in simple steps, and, so far as we have checked, accurately solved. To the serious student and to teachers not too strong in this section of chemistry, the book should be of great value. G. F.

Our Enemy the Termite

By Thomas Elliott Snyder. Revised edition. Pp. xiii+257. (Ithaca, N.Y.: Comstock Publishing Co., Inc.; London: Constable and Co., Ltd., 1948.) 20*s*. net.

THE general form and purpose of this book, the first edition of which was published in 1935, remains unchanged—to provide a popular but accurate work on termites and their control. Progress in knowledge has necessitated the revision of some sections and the complete rewriting of others. This applies to the accounts of biology, nutrition, caste determination and reproduction, and to the description of recent advances in termite control.

Taking the world as a whole, mankind suffers more economic loss from the termites than from any other group of insects. But while the author, who is not only an authority but also an enthusiast on termites, is intent on stressing the importance of his group, he is at great pains to counter the exaggerated fears fostered by the unscrupulous termite-control agencies—almost as great a pest in the United States, it would appear, as the termite itself. In the National Pest Control Association reputable commercial firms and authorities on termites have co-operated in the formulation of control procedures and the development of 'a code of ethics'. The recommendations of the Association are printed in full. They consist almost wholly of prevention by proper building construction (with provisions written into city building-codes if possible) and cure by structural modifications. Chemical treatment for controlling established infestations occupies a secondary place. The book deals primarily with termites of the United States; keys to the genera of these are included, based on winged adults, soldiers and habits.

V. B. W.

How to Live with a Dog

By C. L. B. Hubbard. Pp. 75. (London: Feature Books, Ltd., 1948.) 3*s*. net.

DOG books are usually addressed to professional and amateur dog-breeders and exhibitors, and the owners of ordinary house-dogs are often left to grapple with academic works or pick up their information by hearsay. Mr. C. L. B. Hubbard has tried to help those who wish to make a success of their dog-keeping, and in this little book has condensed much useful information on house-dog management into small compass and plain words. Advice is given on the physical characteristics of dogs, the various breeds, their peculiar behaviour characteristics, their training and grooming, and the way in which they should be fed both in times of plenty and at present.

Mr. Hubbard writes with considerable enthusiasm, and although he attributes to dogs characteristics which are not apparent to everyone, they add to the interest of a book which will be useful to dog lovers.

T. H. H.

SETTLEMENT ON THE CARIBBEAN MAINLAND

TO appreciate, on one hand, Great Britain's centuries-old experience of the Caribbean, and on the other, her difficulty both in maintaining an adequate development of the islands and in beginning the utilization of the mainland interior, is to confront a Colonial paradox. In respect of commerce and industry, as also in matters social and cultural, British Guiana and British Honduras are among the most primitive of British dependencies; yet there is no satisfactory explanation of their neglected condition save the competition of other tropical lands which, not necessarily more favoured in physical endowment, have yet the advantage of a relatively skilled indigenous or immigrant population.

As the Commonwealth frontier tends to recede from monsoonal Asia, the value, in terms of agriculture and commerce, of each remaining tropical dependency becomes ever more significant; and the prospective contribution of the Caribbean lands has recently come to be estimated with an urgency previously unknown. In the interests of the indigenous population as much as in that of its own, Great Britain cannot afford longer to allow this, or any other, region of the Commonwealth to lie neglected.

The findings of the first of two Royal Commissions on the British West Indies were delayed by the Second World War; but the report came soon afterwards[1]. By intention, its geographical scope, though general, referred more particularly to Jamaica and the lesser islands, the social and economic needs of which approached a state of emergency. One vital question concerned the congestion on certain of the islands and the possibility of a planned redistribution of their populations by emigration. Conferences organised in 1944 and 1946 by the Anglo-American Caribbean Commission resolved that a study should be made of the British, Dutch and French Guianas as possible outlets for congestion; and the appointment of the second Royal Commission[2] implemented some of the recommendations. The instructions of the Commission were to advise whether or not migration to the mainland Colonies was possible, and to report whether those Colonies were able, without detriment, to absorb at least some part of the surplus population of the islands.

Such terms of reference necessarily demanded of the Settlement Commission particularly close investigation of both the existing resources of British Guiana and British Honduras and the extent to which they were used and capable of more extensive and intensive utilization. No Royal Commission of our time has been more hindered in its task by the paucity—or, over large areas, by the absolute lack—of scientific records; and the appreciation of men of science will be unstinted for the Commission's recommendation, both to particular Colonial administrations and to the Colonial Office, to make immediately possible certain basic surveys, without which, as preliminaries, effective calculation of the possibilities offered by the hinterlands of Guiana and Honduras cannot be expected. When it has been by no means invariable for reports on Colonial dependencies to be accompanied by more than the most elementary cartographic documents, it is a pleasure to record the greatly improved equipment of maps with which the present report is provided.

Because of widely different space relationships—it is important to recall that the two Colonies are separated by the entire length (1,800 miles) of the Caribbean—and their greatly contrasted areas, it is perhaps not altogether appropriate, on geographical grounds, to include both in one report. Moreover, in respect of history, there is little to associate them. British Honduras, the less important of the two, with only one-tenth the area of British Guiana, is rather more effectively populated, though even so a population density of 7 per square mile is wretchedly inadequate. Wide dispersal of sparse settlement is obviously the main determinant, both of frustration to past efforts towards cultural and economic betterment, and of present hopes to provide homes for the surplus population of the British West Indies.

The realistic language of the report is one of its most satisfying features; as also in the case of its predecessor—the Moyne Report—there is no desire to gloss over the frequently disconcerting evidence of the backward condition of the Colonies. It is clearly shown that there can be no question of rapid improvement in the *tempo* of economic development in these hitherto neglected lands, and that their absorption of immigrants from the crowded islands cannot exceed 100,000 (men, women and children) within the space of the next ten years, even if the organisation of the necessary transport should be assumed. To draw off from the more crowded islands during the next decade a mere 4 or 5 per cent of their total population would seem to be a modest enough project, yet the Commission is aware that the scale of operations, including the great distances to be covered and the need for careful selection of the best types of immigrants from a wide variety of islands, should lead to cautious hopes. The inevitable conclusion from study of the report is that the possibilities of transferring a sufficient number of residents to relieve congestion on the islands are not nearly so important as the problem of selecting immigrants who by physique, outlook and skill are best suited to equip those agricultural enterprises which are recommended.

The reader will find in the report a most able discussion of the climatic prospects for white settlement in this essentially tropical zone. In general, a favourable future for the health of white peoples is foretold, and the significance of this is related to the need—in order to fulfil the development plans recommended—for considerable numbers of skilled Europeans who, it is stated, are not likely to be impeded by tropical disease—granted certain safeguards. On the other hand, close settlement of Europeans is very unlikely, in the official view, except in certain specially suitable areas, of which the Rupununi Savannahs and Kanuki Mountains in Guiana and the Cayo district of Honduras are outstanding instances. But it might be added that the economic inducement to the white man, anywhere in the tropics, to remain in that zone, even for a limited time, must be made particularly attractive. The mainland of tropical America is unlikely, in my opinion, within a foreseeable future, to compete for white labour in a very limited market with certain more favoured tropical lands of higher reputation.

The most notable deficiency in the resources of the two Colonies is their inadequate mineral wealth. Normally, precious stones or metallic ores were the

earliest economic objective in most tropical dependencies before maturity brought a broadening of their commerce and industry. There can be little doubt that, as in Northern Australia, for example, geographical discouragement to the search for easily accessible resources of high value and light weight has been a main cause of present economic stagnation. Moreover, in the case of each Caribbean Colony now under review, the likely return on capital outlay in forestry and agricultural development would certainly be slow, even if the development areas were—as, in fact, they are not—accessible to both labour and markets. Given the complete absence of satisfactory communications in the hinterlands of both Colonies, the prospects for commercial agriculture are necessarily gloomy, as the Commissioners, from abundant evidence, tactfully insist. In their modest words: "If little else results from our recommendations, at least the construction of certain good roads into the interior would lift the veil and open up the substantial possibilities which, we believe, exist. Until that is done we fear that periodic inquiries into the industrial and other possibilities of the interior of the Colony will be impossible to follow up and consequently unfruitful." Although this was written with reference to British Guiana, it applies equally to British Honduras. From their own meagre resources alone, the two Colonies cannot support the expense and organisation of the preliminary surveys and preparation of the ground necessary for the new agricultural and industrial enterprises proposed. In consequence, the report is urgent on the need for the establishment of a local development corporation in each Colony. These bodies would necessarily be dependent upon the Colonial Development Corporation for the greater part of their finances, as well as for the services of expert consultants.

In view of the inadequacy of the data on geographical conditions within each Colony, it was inevitable that the Commission would prepare a statement on the characteristics of the little-known regions which make up the hinterland and form the greater part of each Colony. These geographical statements, which have been woven into the fabric of the report, have been prepared by officers well acquainted with the regional concept of geography; each Colony is analysed on a basis, not of administrative subdivisions which have little relation to geographical realities, but of approximations to 'natural regions'. Indeed, so successful is the geographical presentation that the report should become an essential text for the study of the West Indies.

Space is not available for reference to more than a small proportion of the recommendations intended for the rehabilitation of agriculture which the report presents. Only one further observation is possible here; it refers to sugar production, the industry which easily dominates the life of British Guiana. The expansion expected is indicated by a proposed annual target of 230,000 tons of sugar, or about one-third more than the output for 1946. Although it would seem reasonable to hope, by reason both of the extent of the land capable of sugar-cane cultivation and of the long tradition—from the middle of the seventeenth century onwards—of successful sugar cultivation based largely on East Indian immigrant labour, that the sugar industry would offer a big contribution to the further settlement of British Guiana, the report briefly negatives the probability of this. The reasons do not, however, seem to be adequately explained in the report; and comparison between British Guiana and, for example, Natal, the natural endowment of which for sugar-growing is certainly no greater, makes the official view difficult to accept. The comparison here is with a much smaller territory than British Guiana and one, moreover, with strictly limited possibilities of increased sugar acreage; yet its already planted sugar area is five times greater than that of British Guiana and is much more effectively settled by East Indian immigrants of the type that the Caribbean authorities might well consider further as suitable for settlement.

WALTER FITZGERALD

[1] West India Royal Commission Report. (Cmd. 6607.) (London: H.M. Stationery Office, 1945.) See *Nature*, **157**, 254 (1946).

[2] Colonial Office, Report of the British Guiana and British Honduras Settlement Commission. (Cmd. 7533.) Pp. viii+360. (London: H.M. Stationery Office, 1948.) 7*s.* 6*d.* net.

ROTATION AND TERRESTRIAL MAGNETISM

IN 1923, H. A. Wilson put forward a conjecture whereby an electrically neutral, gravitating mass was supposed to be endowed with some of the properties of a charge; the phenomena of electromagnetism and gravitation, hitherto surprisingly independent, were to be related. The suggested relation was that the motion of the gravitational field of a mass should result in magnetism, just like the motion of the electric field of a charge. If the gravitational field of a mass is as strong as the electric field of a charge, then the one should be as potent in producing magnetism as the other. (Equality of strength of the fields can be defined by means of two equal masses and two equal charges.) For a rotating object this theory would predict proportionality between angular momentum and magnetic moment.

Wilson himself pointed out that this conjecture was not tenable. The rectilinear motion of a mass did not result in any measurable magnetic field, and any such effect would conflict with the well-tried principles of special relativity. It was just a surprising fact that the magnetic moment which this theory would predict for the earth was close to the measured value.

More recently, when evidence was forthcoming regarding the magnetism of some stars and of the sun, Blackett revived great interest in such considerations by suggesting that the same relation would fit remarkably well also in the case of these objects.

At a Geophysical Discussion of the Royal Astronomical Society held on February 25, the present state of such theories and their experimental and observational justification were under discussion. Prof. L. Rosenfeld was in the chair, and opened the discussion with a brief statement regarding the present state of the subject.

Dr. S. Runcorn presented much observational material. He pointed out that recent measurements of stellar magnetic fields, carried out by Babcock in the United States, are in good agreement with the suggested formula, if one accepts the statistical evidence for the rotation speed of such stars. The sun's field is now regarded as variable, but this does not necessarily point to a variable mechanism for the origin of a primary field.

The history of the earth's field has recently been investigated by the examination of ferromagnetic

clay deposited up to one million years ago, and it appears that in that period no major change has occurred. The mean direction of the clay magnetization is the geographical north, and the mean inclination is the one which a central dipole field would have at the latitude of the deposits.

Experiments on the change of the terrestrial field with depth in mines were then discussed by Dr. Runcorn. Such measurements should enable a distinction to be made between fields originating from the core of the earth and those which are of distributed origin, such as the effect suggested by Wilson and Blackett. Such experiments have revealed an unexpected preponderance of local anomalies, even in regions which were thought to be magnetically undisturbed. It appears that such anomalies may be several times as great as the effect sought. Further measurements are in progress, and the degree of disturbance of districts was estimated independently.

Dr. Runcorn also mentioned that a measurable distinction between 'core' and 'distributed' theories of geomagnetism should arise in the neighbourhood of a deep valley or gorge.

Mr. F. Hoyle explained that he had looked for specific processes which would result in stellar magnetism. Indeed, he had found a mechanism which may be expected to generate fields of the observed orders of magnitude. If a cloud of ionized gas is subjected to bombardment by a stream of particles, then the manner in which the momentum of the incoming stream will come to be shared by positive and negative ions is such as to imply a net current. Such a process must occur in the atmosphere of a star which is acquiring material from without, which does not originally possess the angular motion of the star.

On the question of terrestrial magnetism, Mr. Hoyle remarked that there are a number of possibilities of specific processes. The long decay-time of currents in the earth left open the possibility of magnetization in the past by processes which do not occur with similar intensity now. Streams of ionized gas are known to reach us from places in the vicinity of sunspots, and such streams will transport a magnetic field. It would be legitimate, though perhaps somewhat strained, to suppose that much more violent solar outbursts in the past were responsible for the transport of magnetism to the earth. Another point of view which he had recently come to consider, together with Mr. T. Gold, was that the objections which had been raised against Gilbert's original theory were inadequate, and that permanent magnetism may, in fact, cause the earth's field.

The present writer's contribution was concerned with the theoretical aspects of a fundamental law connecting rotation of neutral masses with magnetism. Blackett's empirical formula, in which the angular momentum is proportional to the magnetic moment, could not, in itself, be a statement of a physical law. The amount of angular momentum which is ascribed to a system depends entirely on the position and state of motion of the reference point chosen; but magnetic moment does not have a similar dependence on the co-ordinate frame. The suggestion is that the real law is such as to reduce to the formula under the conditions satisfied by the earth and the stars, when their centre is taken as the reference point for the computation of the angular momentum. The angular momentum in orbits cannot have any such magnetic effects, as can be seen from direct experiment, from considerations of special relativity, and from the divergence of such an effect for rectilinear motion. If orbital motion is to have no such effect, then a self-gravitating disk would have to show no effect at that particular rotation speed which made the path of each constituent particle a free orbit.

There are four conditions which one might expect such a new, fundamental law to satisfy:

(1) *Differential Law.* It must be possible to consider separately the contribution to the total field which arises from any one mass element. The definition of any such contribution must require no more than a specification (however detailed) of physical conditions which would be measurable at that element.

(2) *Special Relativity.* The law must not give preference to one particular inertial frame over all others.

(3) *Equality of Inert and Gravitating Mass.* There must be no distinction between the effects on a mass of a gravitational field or of an acceleration.

(4) *Magnitude and Symmetry.* The law should result in a field of the right order of magnitude and symmetry for the earth; but it must not result in effects which could not have been overlooked in the laboratory.

The proposal of a 'fundamental law' implies that only dynamical quantities should be relevant to the magnetic contribution of each mass element. Conditions like temperature or conductivity are to play no part, if any significance is to be attached to the correlation between terrestrial and stellar fields.

It appears to be impossible to meet this set of conditions. Any combination of dynamical quantities which affect an element of mass partaking in the earth's motion can be made incomparably greater in the laboratory; any law which can be constructed from those quantities must always imply an obvious laboratory effect, if it is to account for the earth's field.

The Blackett formula avoids this difficulty. There a mass-element partaking in the earth's motion should have a magnetic effect proportional to the square of its distance from the earth's axis; but no such favourable factor would enter in the case of a spinning object in the laboratory. But the distance from the earth's axis is not a physical condition of a mass-element, as it is not a locally measurable quantity; and for this reason the formula offends against condition (1).

It is concluded that we lack any suggestion of a physical quantity to be related to magnetism in a novel way; the alternative view would be that one of the conditions could be dropped, but it is unlikely that such a view would come to be held.

Prof. P. M. S. Blackett described the reasons which had caused Wilson to reject the original hypothesis; but Wilson had not been aware of the kind of evidence which Dr. Runcorn had presented, and which appeared to be very compelling. His own view was that a solution of the difficulties could be found in a reinterpretation of the quantities appearing in the formula. The radius appearing in the formula for the angular momentum requires revision, and it might be interpreted as the radius of curvature of the modified gravitational equipotentials at each contributing mass-element. This definition should be acceptable, as such a radius of curvature is a quantity which can, in principle, be detected everywhere. Two plumb-lines, a certain distance apart, will point in

directions converging at the centre of the earth. Their separation and the angle between them are hence a measure of their distance from the centre. The magnetic contribution of one mass-element can then be taken as being proportional to the product of its mass, angular velocity, and the square of this distance which can be defined there, as the plumb-line example shows. All the quantities entering now are of local significance as required. On the basis of such an interpretation no difficulty would arise in the case of an orbital motion. Plumb-lines at neighbouring points on a planet would converge on the centre of the planet, and hence only the spin would count.

Prof. Blackett then mentioned a suggestion for a laboratory experiment, which would be more direct than the measurements of the earth's field in mines or across canyons. A small massive object at rest in the laboratory should make a contribution to the earth's field, which would result in a local effect of the order of 10^{-8} gauss. Though small, this would be measurable.

The general discussion which followed touched upon many topics, but only those dealing with the theoretical approach suggested by Prof. Blackett will be presented here; although, indeed, many other stimulating points of view were advanced.

The writer said he considers the radius of curvature of the geopotentials an unsuitable length to enter into the Blackett formula. It is true that a local determination of this length is possible in principle; but locally it may easily give values which are arbitrarily large. Two plumb-lines placed closely in between two small gravitating objects may well hang parallel. The proposed interpretation would then imply an arbitrarily large magnetic contribution of matter in such localities. A slowly rotating, horizontal wheel would be another example of a locality where plumb-lines may all be parallel. The use of a geometrical property of a field, without regard to its strength, for determining the strength of an effect, must lead to the anomaly that an arbitrarily small change of circumstances may have an arbitrarily large effect.

The suggestion of a new law of magnetism is hence still quite vague. No actual physical quantity has been suggested which might be related, by way of a new law, to the magnetism of large rotating bodies. In these circumstances, even the experimental approach is severely handicapped, for it is much harder to search for a new relation than to prove an asserted law.

T. GOLD

LEAF FORM AND FUNCTION*

By SIR EDWARD SALISBURY, C.B.E., F.R.S.

THE green leaf of the flowering plant is perhaps the most important structure in the world, since upon it in large measure depends the maintenance of life upon the earth's surface. While the law of entropy applies to all our surroundings, the green leaf is a part of Nature that perhaps more than any other is doing a little winding up in a cosmos that is mostly running down.

The chemical processes which are carried on in the leaf are complex and involve a chain of reactions and enzyme activities the details of which are still in many respects obscure; but as we are concerned more with the factory itself than the details of the processes that go on within it, we can take for granted the elaborate series of chemical changes accelerated by enzyme action. For though these may well demand an organisation of the living protoplasm of great importance, the tools for exploring the submicroscopic structure of the cell are only now being developed.

The older botanists fully recognized that the spiral arrangements which leaves very commonly exhibit in their attachment to the stem tend to ensure the maximum display of the leaf surfaces with the minimum of overlap, and that the changes in growth of leaf stalks which accompany any changes in the direction of incident light bring about the so-called leaf mosaics which minimize the competition for light between the leaves of the same plant or branch. What they did not appreciate was the complexity of the phenomenon and of the interaction between light and growth. For not only is the direction of the leaf stalk and orientation of the blade involved but also the amount and effect of the growth-promoting substances, produced by the apical buds and by the leaves themselves. These growth hormones stimulate cell enlargement in varying degrees, according to the intensity of the light (maximum leaf area usually being attained in partial shade) and also inhibit in more or less degree the development of axillary buds.

The interrelations of growth effect that fine adjustment that brings about the display of the photosynthetic pigments to the best advantage. The various types of spacing in a spiral, such that there are always three leaves in any single circle of the stem, suggest a growing point that behaves as the multicellular equivalent of a three-sided apical cell found in many pteridophyte and gymnosperm embryos. This primary tendency is, however, modified by the competition for food and by space relations imposed by the combined effects of the rate of production of leaf rudiments on one hand and the rate of stem elongation on the other.

In general, intense light inhibits the effect of growth-promoting substances upon stem elongations so that, in bright light, the internodes are short and the foliage crowded, whereas in dull light the internodes lengthen and the leaves are widely spaced. Since bright light causes decomposition of the pigments, these reactions are obviously beneficial; but for leaf blades the optimum light intensity for permitting the growth-promoting substances to operate at a maximum is apparently higher than for stems, though this is not true of monocotyledonous leaves which are comparable to leaf stalks in their behaviour. In woodland plants there is often a marked increase in the size of the leaf blades with the diminution of the light consequent upon the canopy development of the foliage above in spring.

The span of life of leaves is usually short. Deciduous trees, such as most of the native species of Britain, bear leaves that only function for about six months, though their loss and annual renewal permit a large leaf surface with evasion of an adverse season. Evergreen leaves such as those of the holly and ivy may live for more than two years, while the needles of coniferous trees often persist for 2–12 years, according to the species. In general, it would appear that the length of life-span of leaves is related to their degree of activity. The giant leaves of *Victoria regia* with their rapid metabolism have a short life; they only function

*Substance of a Friday Evening Discourse entitled "Leaves" delivered at the Royal Institution on February 4.

for a few months, whereas that remarkable, very slow-growing, desert plant, *Welwitschia*, which probably attains to an age of more than a hundred years, retains its one pair of leaves throughout life.

The surface presented to the sun's rays by the individual leaf is very diverse. The leaf of a beech tree presents a total surface of nearly seventy times that of a single needle of the spruce fir, yet what the coniferous tree lacks in size of the individual leaf it makes up in their number, so that the total leaf surface of a mature tree is much the same for each.

The feature that possibly impresses us most is the infinite variety of leaves and wide range of size. If, for example, we consider the forms which leaves present in each of the successive strata or stories of an English woodland, we shall note that, despite the comparative uniformity of the conditions at the ground-level or within the leaf canopy of the trees, the foliage presents the greatest diversity of external appearance. We are, I think, forced to conclude that in respect to leaf form and size a variety of types have similar degrees of efficiency, and that because the same end can be attained in a multiplicity of ways, each with similar survival value, the diverse variation is permitted free play unchecked by the forces of natural selection. But though the facts appear to testify to the truth of this generalization, it is nevertheless apparent that certain features of leaf form are especially appropriate to particular conditions. It can scarcely be doubted that the multiplicity of small units rather than fewer and larger ones is an advantageous feature in exposed situations, militating against mechanical damage by wind, the more so that the rapidity of orientation of the leaves and leaflets, like vanes in the wind stream, is facilitated when these are small. A further advantage of small leaves is that despite the larger surface-to-volume ratio which they present there is actually a reduction of excessive water-loss owing to the fact that there is less deformation of the blade by bending. The repeated distortion of the leaves by successive gusts of wind, which may be very marked when leaf blades are large, has the effect of compressing the air spaces in the interior of the leaf and thus causing expulsion of the moist air. This and the mechanical resistance to desiccation are perhaps the most important reasons why small simple leaves, or compound leaves with small leaflets, are particularly a feature of the drier and more arid areas, whereas large simple leaves are a prominent feature of the still, moist atmosphere of the tropical rain-forest.

The general structure of the leaf is admirably fitted to fulfil its physiological purpose and to meet the mechanical strains imposed upon it.

The relation of structure to mechanical stress is nowhere better seen than in the leaf stalk. For most leaves this has the form of an inverted arch, and the woody strands which it contains likewise conform to this plan. But in the leaves of rosette plants where the blades rest on and are supported by the soil, the arched form is either absent or so flattened as to be virtually non-evident.

The inverted arch, while admirably suited to support the downward thrust of the blade, readily permits a twisting movement and does not inhibit the blade assuming the 'edge-on' position in high winds, thus materially diminishing the mechanical strain on the individual leaf and on the plant as a whole.

Further, if we examine leaves in which the strain is symmetrical, as in a *Nelumbium* or a *Gunnera*, instead of an open arch we find the mechanical tissues are also more or less symmetrically distributed.

It is justifiable to regard the general architecture of the leaf as determined to a considerable extent by mechanical efficiency.

The leaf has been compared to a half-stem; but, in fact, to regard the leaf as a modified stem structure is no more warranted than to consider the stem as a modified leaf. It is true that, for example, a few leaves like those of *Kalanchoë coccinea* bear shoots, but so do many roots, while the leaf-like stem, as of *Phyllanthus*, and the stem-like leaf thereby emphasize that both alike are parts of a common plant body, each admirably suited to its functional requirements and variously specialized to those ends.

To the diversity of leaf-form probably the most important single causal influence is the transport system of the plant represented by the skeleton of vascular bundles in the stalk and blade. Three main types are presented to us, namely, the pinnate, the divergent and the convergent. There are all types of elaboration of these three fundamental types of structure, mainly depending on the degree of ramification of the subsidiary veins and the extent to which they join together.

The strikingly uniform character of the leaves of most monocotyledons warrants comparison with the stalk and midrib of the normal dicotyledonous leaf prior to the development of its lamina. This difference is probably correlated with the usual absence of meristematic activity within the bundles of the monocotyledonous leaf. In consequence, the number and extent of the original bundles must be such as to meet the needs of the mature leaf. The green tissue is, as it were, intercalated between the already existing bundles which extend with the growth of the leaf. On the other hand, in dicotyledons submarginal growth forms a blade in which branch bundles develop, and the small number of main strands in the midrib are able to increase in size with the growth of the demands upon translocation.

It is noteworthy that in such dicotyledonous leaves as have bundles which exhibit little secondary thickening their number may be large although the increase is not directly proportional to the leaf area. In the rhubarb, for example, a large leaf of more than half a square metre in area had a leaf-stalk with three hundred bundles, and one of 1/20 sq. m. had eighty-three. There are dicotyledonous leaves, however, which, like those of *Eryngium agave* and *Ranunculus graminæfolius*, are comparable to the monocotyledonous leaf. It is perhaps the space relations that, as much as any other factor, account for the presence of bundles with inverted orientation both here and in the monocotyledonous leaf.

The development of the fan-shaped or feather-like leaves of palms shows that their apparent leaflets are, in fact, derived not by outgrowths from the leaf stalk, as in dicotyledons, but by a complicated process of invagination and subsequent splitting between the bundles, so that the leaves of palms fall into place as elaborations of the general monocotyledonous pattern.

Growth involves both cell differentiation and expansion, and the latter phase in particular is dependent on the maintenance of a turgid condition. It is therefore obvious that both in respect to the food material, requisite for differentiation of new units, and the water supply, necessary for their expansion, conditions are most favourable immediately surrounding the vascular strands and become

less so as the distance of the cells from the veins increases. Moreover, this diminution of conditions favourable to growth is accentuated with increasing aridity of the environment in which the leaf develops. Thus, on *a priori* considerations, the drier the habitat of a species the more the development of the lamina might be expected to be restricted to the immediate vicinity of the veins, so that a leaf with feather-like veining will appear deeply cut, whereas lamina development should tend to fill in between the veins when conditions are favourable in respect to humidity and food supply. In fact, one may suggest that where conditions are unfavourable for lateral transport the leaf blade, like human habitations under similar conditions, tends to exhibit 'ribbon development'.

Let us see how far such a concept helps us to understand leaf-form and is consistent with experimental facts. The epidermis becomes differentiated at a very early stage by conversion of epidermal cells into stomata. Some years ago, I was able to show that the varying number of stomata in a unit area of the leaf of any particular species was, in fact, dependent on the extent to which the unaltered epidermal cells expanded, and not, to any significant extent, upon differences in the number of stomata formed. Thus, if we express the number of stomata (S) as a percentage of the total of converted and normal epidermal cells, this stomatal index $\left(\frac{S}{E+S} \times 100\right)$ was found to be a specific character that varied often within narrow limits for plants of the same species, growing under widely different conditions. Thus, the leaves of *Caltha* growing in mud and dry soil, respectively, though of vastly different sizes, alike had an index of 11–12. Hence the number of stomata on a given area of the leaf will decrease with the extent of expansion that has taken place. Since the number of stomata in a given area was found to increase as we pass away from the midrib to the leaf margin and from the base of the leaf towards its tip, we can infer that conditions for growth decrease in favourability as the distance from the main sources of transport increases.

The significance of leaf shape is presented in another form by those plants which produce more than one type of foliage on the same individual. In some such it is obvious that two types of foliage are actually produced under different environmental conditions; but in others the changed conditions are internal rather than external. If we examine the leaves of such a common plant as the dandelion we find that, in fact, the shape of the leaf changes with the age of the individual. We find that leaves of young individuals are almost entire; but as the individual grows older it produces leaves that are more and more deeply dissected, until finally, at the time of flowering, the leaf form of the adult is scarcely recognizable as belonging to the same species as that of leaves produced in its juvenile condition. Soon after flowering is past the new leaves formed resume the simpler, more juvenile form, and it is not unreasonable to regard the increasing dissection and restriction of blade development to the neighbourhood of the veins, during the formation and development of flowers, as due in large part to diversion of food materials.

Comparison between the basal leaves and stem leaves of the same plant (for example, *Scabiosa columbaria*) and sun and shade leaves (for example, *Quercus cerris*) also tend to bear out our thesis. Moreover, the restricted development of the lamina in dry conditions imposes a smaller demand on the food supply in this direction and is usually accompanied by a greater development of the veins, so that the cauline or sun leaf has a more richly branched vein system and may be more deeply dissected than the vein system of the shade leaf would lead one to expect. Thus in a condition of extreme physiological drought the stag's-horn plantain develops the *pygmea* form with a simple untoothed leaf. In conditions of better nutrition, but dry atmosphere, the leaf is pinnately lobed, but the lobes are narrow; whereas with copious nutrition and moist conditions the lamina develops into broad lobes throughout. These effects of the external and internal environment must be considered in relation to any tendency in the juvenile plant to produce an ancestral, less specialized type of foliage. The two influences may be additive or antagonistic in their effects.

If we cut a crown off an old dandelion plant with very highly dissected foliage, we know all too well, from our gardening experience, that a new crown soon develops. From these new buds, the foliage, although arising from an old dandelion plant, produces the juvenile type of blade. In the common ivy, it is the juvenile foliage that has the familiar lobed form, whereas the mature individual produces simple foliage of rhomboidal shape without any lobing, and in the mulberry, leaves of sucker shoots are often deeply lobed while those of the adult are simple. This change in the ivy is definitely associated with the formation of flowers and fruit. In some other plants, too, the change in leaf-form is clearly associated with the physiological changes that are sometimes referred to as 'ripeness to flower'.

It is, indeed, probable that the forms which leaves assume whether in the seedling or adult conditions can vary over a wide range without impairment of their efficiency, and conditions of nutrition play a considerable part in determining the differences between leaves of the same individual.

It is only when the living cells in the interior of the leaf are well supplied with water that food production is maintained. As soon as there is incipient wilting, the rate of production begins to fall off and decreases rapidly as flaccidity increases. Thus any feature of external form or internal structure that minimizes the water-loss and thereby prolongs the condition of turgidity will augment the food supply and therefore the success of the plant. Of anatomical factors that promote this retention of moisture none is more important than the structural features which resist compression and thereby not merely the active expulsion of moisture by bending, but also the loss of water molecules by evaporation.

In no leaves are mechanical resistances to water-loss better seen than in the leaves of many Proteaceous plants and pines from the arid areas. Not merely is the leaf of such a pine protected by a thick-walled epidermis that serves as a water jacket, but also the bands of thick-walled tissue constitute an almost complete cylinder, so that any shrinkage that occurs from water loss must overcome the very considerable resistance offered to compression.

Free gaseous diffusion of carbon dioxide from the surrounding atmosphere into the chlorophyll-containing cell of the leaf is assured by the abundant stomata, which in the oak leaf, for example, may number more than 140,000 in an area the size of a

sixpence; and even in the wood sorrel, which, in common with other herbs of shady situations, has relatively few stomata, a single leaflet will probably have between twenty and thirty thousand stomata. Their distribution exhibits a number of interesting features. While in many plants the stomata are confined to the lower surface of the leaf which is the more sheltered in respect to removal of water vapour by evaporation, yet in rosette leaves and mat plants and species of shady damp habitats the stomata may be as numerous or even more so in the skin of the upper surface than the lower. Since the stoma has an elliptical pore bordered by two sausage-like guard cells, upon the turgidity of which the opening or closure of the aperture depends, each pore has a definite axis.

There is a marked difference in the orientation of the stomata in the leaves of most dicotyledonous and monocotyledonous leaves. In the latter all the stomata usually show a parallel trend, while in the former the stomata appear orientated in an irregular way. But close study of such a leaf as that of the lesser celandine will show that, in fact, there is a very high degree of correlation between orientation of the individual stomata and the direction of the adjacent veins. It would, in fact, appear to be highly probable that the orientation of stomata is dependent upon the direction of the stresses occurring in the epidermis during the period that these structures develop. The leaves of monocotyledons, as we have seen, are more nearly comparable to the leaf-stalk and midrib of the dicotyledons, and nearly all the bundles trend in the same direction, so the stresses and strains may be described as polarized. Here we find the stomata parallel just as they are in the epidermis of the leaf-stalks of dicotyledons; but in the lamina of the dicotyledons the bundles are orientated in a network that spreads in all directions, and the orientation of each stoma would appear to be dominated by the resultant of the tensions to which the tissues are subjected.

In the herb Paris, a monocotyledon with unusually irregular venation, the stomata are also irregularly orientated, and in this shade species we may note also that the epidermis no longer functions as a water jacket protecting the chlorophyll tissue beneath, as in the leaves of open habitat species, but itself contains chloroplasts. On the other hand, in some dicotyledonous leaves (for example, *Silene maritima*) where the stresses are polarized in a manner similar to midribs, the stomata exhibit a regular and parallel orientation.

We have previously noted that for any given species the drier the environment, both internal and external, the greater is the density of the stomata. Since, however, only the widest of spacing will preclude mutual interference of evaporation from neighbouring pores, the increased density induced by external conditions has little effect in augmenting the capacity of the leaf to lose water.

The necessity for free gaseous exchange that ensures an adequate supply of carbon dioxide also involves the risk of excessive water-loss. Since the rate of manufacture by the leaves decreases with loss of turgidity both directly and through closure of the stomata, any structural features which retard excessive water-loss and prolong the period of turgidity will increase the food income. Thus transpiration checks may be beneficial even though their influence be slight. The thick waxy cuticle, the dense covering of hairs and the sunken stomata do not stop water loss, but may greatly retard it and so prolong the working period. It is only when the leaf is appreciably wilted that the mechanism of closure of the stomata comes into play as the most important check on water loss.

But if the danger of excessive water-loss is perhaps the most obvious in the mature leaf, the excessive intake of water is possibly the greatest risk in the juvenile condition. It is therefore significant that the parts of the leaf which are the earliest to mature, namely, the leaf tip and the tips of the leaf teeth, corresponding to bundle endings, are the site of groups of permanently open stomata that serve as water pores. From these the water forced out of the vessels escapes as vapour or, in humid conditions, collects as liquid on the leaf teeth like localized dew drops. Sometimes the safety valves are extra floral nectaries, and the nectaries of flowers themselves are to be regarded as specialized derivatives of such safeguards in the reproductive shoot.

OBITUARIES

Prof. Walter Garstang

THROUGH the death of Prof. Walter Garstang on February 23, at the age of eighty-one, zoology has lost one of its most prominent personalities—scholar, investigator and teacher. The son of Dr. W. Garstang of Blackburn, he entered Jesus College, Oxford, as a medical student in 1884, and, abandoning that course, graduated with honours in zoology. In 1888 he was appointed as assistant to G. C. Bourne, the first director of the Plymouth Marine Laboratory, and a few years later became assistant naturalist there. The year 1893 saw him back again in Oxford as Fellow of Lincoln College and lecturer in zoology under Ray Lankester; but in 1897 he was again established in Plymouth as chief naturalist in charge of fishery investigations. In 1901, he directed from Plymouth, and later from Lowestoft, Great Britain's part of the larger international programme of research on the North Sea fisheries. In 1907, the University of Leeds invited him to the chair of zoology—a position which he accepted and continued to hold until 1933, when he retired to Oxford to continue his researches there.

Thus Garstang's zoological career falls into three phases. First come those researches into the morphology and biology of marine invertebrates which were carried out in the early Plymouth and Oxford years when he was laying the foundations of his profound knowledge of the sea. Then followed the application of this knowledge to investigations on fisheries, and his work on the natural history of the plaice of the North Sea will long serve as a model for such research. By extensive age-determinations and measurements, and particularly by liberating vast numbers of marked fish (to be returned when recaptured by fishermen) he studied their natural growth-rates and migrations in different areas. He also transplanted young marked plaice from the crowded nursing grounds of the Dogger Bank, and, by showing that in two years they grew to more than twice the size of those left behind, he pointed the way to a future farming of the sea. Some of his ideas on this subject appear in his Buckland Lectures for 1929. It is not surprising that he became one of the architects of the International Council for the Exploration of the

Sea. Nor is it to be wondered at that he was the able and trusted spokesman for the industry at the then Board of Agriculture and Fisheries—sometimes, it may be said, to the discomfiture of scientific colleagues with whom he did not always see eye to eye.

The quality of independence which he possessed abundantly must surely have accounted for his translation to the chair at Leeds in 1907, for it was then that the Government took over the fishery investigations. Great as were his contributions to marine zoology, both academic and economic, zoology was the gainer by this change. For his virile mind was thereby released to pursue the philosophical and speculative tasks for which he was so patently fitted. It permitted, too, that his personality should be felt and enjoyed by the many generations of his students. He inspired them with a love for the subject, and, more, he made them think and seek for themselves. His class lectures were unique in that they often ignored the channels prescribed by syllabus and became instead a forum in which he argued with himself on his own philosophical speculations. Here were first sown the seeds of his classical re-statement of the biogenetic law. It was in his degree-course lectures, too, that his ideas on larval forms and vertebrate ancestry first appeared. Here it was that he began to build up his logical case for the influence of larval modifications on adult evolution by the process of pædomorphosis, a word of his own coining. During this time he developed a reputation as a world authority on tunicates, and used his knowledge on their morphology to develop his theme on chordate phylogeny.

Garstang never isolated himself from the outside world. Over many years and through his active presidency of the Yorkshire Naturalists' Union, the Leeds Naturalists' and the Leeds Philosophical and Literary Society he stimulated the interest of the amateur biologists of Yorkshire. He was president of Section D of the British Association at the Glasgow meeting in 1929. After retirement, he continued his investigations, and a steady stream of papers appeared right to the end. Before the War he renewed his study of marine animals and particularly of larval forms by visits to Bermuda. His critical grasp of detail emerges in his criticism of modern molluscan nomenclature and, to greater effect still, in the remarkable treatise on the morphology and relations of the Siphonophora, which was published as he was approaching his eightieth year.

Few who go from us will leave behind so much affection and such a sense of gratitude. It is inevitable that his students will remember Garstang for his perpetual youth and his genial kindness. They will think of their visits with him to the marine station which he established at Robin Hood's Bay; of teas in the laboratory at which he and Mrs. Garstang were generous hosts and at which the week's problems were discussed; and of their open house at Meanwood where all students were welcome. He will also be remembered for his interpretation of bird-song—something of a poetic interlude in his scientific work—the enthusiasm for which he easily imparted to those who joined him in this delightful pursuit. It is good to know that he lived always a happy and full life in the midst of a devoted family who shared his interests. His wife, whom he married as Miss Lucy Ackroyd of Newnham College in 1895, died in 1942. They are survived by a son and five daughters.

L. EASTHAM

Prof. Bailey Willis

'EARTHQUAKE WILLIS', one of the most colourful and widely known figures in American geology, has passed away. The record says he died at the age of ninety-one; but those who, a short while ago, saw him striding jauntily across the Stanford campus, riding his bicycle to the gymnasium, or arguing vehemently with embryo geologists, will tell you that he was still a student eagerly learning his trade. First among the impressions he leaves is one of perennially vigorous, inquiring youth.

A few days before he died, he completed another part of his autobiography, "Friendly China", sequel to "Yankee in Patagonia". Yet his first geological paper appeared sixty-five years before. He graduated in the late seventies as an engineer from Columbia, and for the rest of his days his prime concern was with the mechanics of mountain-building. The colours of his spirited landscape-paintings re-appear in all his writings, as when, discussing mountain arcs, he asked: "Are the wrinkles on our face there because the muscles have pushed or because the flesh has shrunk or the skin expanded?" It was the physiognomy of the earth's face that specially intrigued him, and not so much the details as the fundamental causes. Let some of his chief papers be recalled. His "Mechanics of Appalachian Structure", dated 1893, remains a classic for development of the concept of competent and incompetent beds and the role of initial dips in folding. His writings on "The East African Plateaus" and on "The Dead Sea" advocate the compressional origin of the great rift valleys; his articles on the coast ranges of California emphasize shearing along faults as a cause of deformation, and compression along deep shears as a cause of vertical uplift.

For him, the theory of continental drift was "a fairy tale, ein Märchen"; no need to invoke it to answer the demands of palæontology when temporary isthmian links might do the same with less affront to his concepts of earth-mechanics. For him, the propulsive force in earth-movements was volume-change at depth, brought on by the rise of 'asthenoliths', blisters of molten rock, developed by decay of radioactive substances scattered irregularly beneath the crust. The earth is growing hotter; the rising blisters expand upward, and their covering rocks, becoming foliated by recrystallization, spread sideways. Discoidal surfaces of shear form in the lithosphere; the disks rise and fall. Metamorphism is no less the cause than the result of orogeny.

These were among the views Bailey Willis championed with vigorous pen and fluent speech, and his travels took him over most of the globe in search of evidence. The same search inspired his large works on the geologic map, the palæogeographic maps, and the index to the stratigraphy of North America.

His training as an engineer led him naturally to seismology. For six years he presided over the Seismological Society of America; his influence had much to do with the important part now played in seismology by Californian institutions. He was greatly concerned with earthquake insurance, and did much to improve the building codes in California. Indeed his reputation grew until he found it hard to allay rumours that he had powers of prediction.

Honours came to him from many lands. He was president of the Geological Society of America and recipient of its highest award, the Penrose Medal.

The Geological Society of London elected him a foreign member, and the Royal Geographical Society an honorary member. Germany, France and Belgium paid him tribute.

The Stanford campus is no longer graced by his striking figure and courteous manner, but his example remains of how old age may best be spent, in exercise, study and cultivation of the affection of one's fellows. He closed his full life, as he closed his speech accepting the Penrose Medal, "with a cheer to Youth that carries on in the search of Truth".

HOWEL WILLIAMS

NEWS and VIEWS

Wool Industries Research Association: Mr. B. H. Wilsdon

THE resignation of Mr. B. H. Wilsdon offers the opportunity to place on record some of the work accomplished during his fourteen years directorship of the Wool Industries Research Association. His experience before going to Torridon included research at Oxford, varied activities as professor of chemistry at Lahore, and five years as superintendent of laboratories at the Building Research Station of the Department of Scientific and Industrial Research. He found the vitality at Torridon at a low ebb; but under his stewardship the output of research increased steadily in volume and quality, and the chief successes of the teams he gathered together and encouraged are impressive. Torridon became the birthplace of partition chromatography. Described by Sir Robert Robinson as the greatest advance in protein chemistry since the work of Fischer, it spread rapidly to many important laboratories faced with complex mixtures of organic and inorganic substances. By its aid and by other methods, significant contributions were made to our knowledge of the chemical constitution of wool. In the more technical field, the dry chlorination process for producing non-felting wool was ready at the outbreak of war in 1939, together with the 'Warnorm' certification mark, to help ensure the unshrinkability of the socks and underwear supplied to the Forces. Another war-time activity, carried forward with great energy, was the impregnation of fabrics with active charcoal, originally as an anti-gas measure, but later used extensively to absorb bad odour from anaerobically dressed wounds. Noteworthy advances were also made in the application of physics: a clearer insight into the physical factors underlying the comfort of wool clothing was gained, and studies on machinery and operational research pointed the way to post-war economies in woollen carding and worsted drawing. In addition, statistics was brought to bear on testing methods and on wool metrology. All this work was widely appreciated in Australia and in the United States, but less so in Great Britain. This is a common occurrence in the life of a growing institution; even the active workers do not appreciate the full value of their collective efforts. Later recorders will, it can be safely assumed, point to Mr. Wilsdon's directorship as a very bright period in the scientific history of Torridon.

Social Implications of Scientific Progress

AN important event of the year for the world of science is the three-day Convocation at the Massachusetts Institute of Technology, Cambridge, Mass., which opened on March 31. The general theme of the Convocation is "The Social Implications of Scientific Progress at the Mid-Century Point", and two opening speeches were delivered by Mr. Winston Churchill and Mr. Harry S. Truman. Addresses given by eminent men from many walks of life and from various parts of the world fall under the following six main divisions: "The Problem of World Production"; "The Problem of the Underdeveloped Area"; "Science, Materialism and the Human Spirit"; "The Role of the Individual in a World of Institutions"; "Specialization in Twentieth Century Education"; "The State, Industry and the University". Among the British speakers are Sir Henry Tizard, chairman of the Defence Research Policy Committee of the Ministry of Defence; Lord Hailey; and Sir Richard Livingstone, president of Corpus Christi College, Oxford. Speakers from other countries include Sir Ramaswami Mudaliar, president of the United Nations Economic and Social Council, and Prime Minister of Mysore State; M. Pierre Ryckmans, Belgian representative on the Trusteeship Council of the United Nations; Mr. Carlos Contreras, president of the National Planning Association of Mexico; and Mr. Oswaldo Aranha, formerly Brazilian Ambassador to the United States. At the end of the Convocation, the ceremony of inauguration of Dr. James Rhyne Killian, jun., as president of the Massachusetts Institute of Technology, takes place, and one of the addresses of welcome to Dr. Killian is by Mr. David A. Shepard, honorary secretary in London of the Institute, and chairman of the Anglo-American Oil Co.

Manchester Joint Research Council: Report for 1948

THE Manchester Joint Research Council, established in 1945, has for the first time issued a printed annual report. This report, covering the year 1948, pays tribute to the work of Mr. A. H. S. Hinchcliffe, as chairman, and Sir John Stopford, as treasurer, during the first, formative years, and they have now been succeeded by Sir E. Raymond Streat and Sir Charles G. Renold, respectively. One of the most successful ventures of the year was the meeting in February, addressed by Dr. A. King, which was a result of the efforts by the Council to supply information to the Department of Scientific and Industrial Research on the need for sponsored research activities in the north-west of England. The resulting discussion further indicated that for many years to come the Council is likely to be closely concerned with improving the technology of the small firm and with encouraging accelerated development and inventiveness in industry generally. In an effort to ascertain how the Council might apply itself to discovering the hindrances which prevent firms from using knowledge already available, Sir Henry Tizard was invited to the October meeting of the Council. Sir Henry's remarks reinforced the opinion that an objective and scientific investigation of the needs of industry in this area would be a substantial contribution; and at the annual meeting on February 28, the joint honorary secretary, Mr. J. Ainsley, indicated the broad pattern of the inquiry which the Council proposed to pursue. The intention was for a team of experienced men to

visit a cross-section of industry, some three hundred or three hundred and fifty firms, and to investigate how scientific information reaches a firm, the obstacles, and the methods by which the obstacles might be overcome. The inquiry might reveal the need for a regional institute of the type of the Mellon Institute; but an attempt would also be made to assess the means whereby scientific methods and technical knowledge could immediately be applied to increase productivity. New staff would be required for the survey, and in this it was hoped that industrial establishments would assist.

Activities of Political and Economic Planning

A BROADSHEET, "Review of a Programme", issued by Political and Economic Planning (No. 289, October 18, 1948) is of general interest as, besides reviewing the progress of work outlined in a similar broadsheet in 1946, it describes the new work on which P E P is now engaged. Some of this work, notably the inquiry into the future of British universities and that into the relations between Government and industry in the new context of central economic planning, is of special interest here. The first of these will draw on and develop the discussion of university training in the report on man-power policy now completed, as well as the examination of the administrative framework of the education system in the broadsheet on "Councils and their Schools". The group conducting the inquiry consists mainly of university 'dons' with a number of laymen and of corresponding members. The second inquiry, which is not yet properly under way, will examine first the assumptions that must be made about the nature of the instructions which the Government gives to industry and the conditions which make it necessary for the State to issue them. Next, the inquiry will examine in broad terms those measures of Government which affect the working of industry, before proceeding to consider the common purpose which business shares with industry, the nature of the general decisions which Government has to take, the division of responsibility between Government and industry for the execution of policy and the methods and machinery by which policy is drawn up in effective collaboration with industry. The central problem of the inquiry will be to discover how programmes can be met without the Government having to decide in detail what people are to make and where they are to work.

As regards the work already carried out, the broadsheet gives a concise review of the progress made and indicates the broadsheets or reports already published and the position of others which are in the final stages. These include a report on the engineering industries and the various broadsheets from the "Active Democracy" Group. A third major inquiry, into housing policy, is being conducted by a group formed in July 1948 to report in 1950 on the principal elements of a long-term housing policy, and particularly to define the issues, the possible alternatives and the implications involved in each.

German Jute Industry during 1939–45

IN B.I.O.S. Overall Report No. 17 (London: H.M. Stationery Office, 1949. 6*d*.) the British Jute Trade Research Association presents in co-ordinated form data on the jute industry in Germany during the period 1939–45, which has been given in two earlier main reports from the British Intelligence Objectives Sub-Committee and in other intelligence surveys. Alternative raw materials used in this industry during the period were mainly paper; but regenerated cellulose and naturally occurring cellulosic fibres of European origin, such as green flax and green hemp, were also used. The report includes notes on the emulsifying agents, such as 'Emulphors', used in batching jute, on sizing agents in use, as well as products such as 'Preventols' used for protecting starches and jute against mildew attack. The most important treatment used for rot-proofing appears to be the cuprammonium process, and some work has also been carried out on flame-proofing and water-proofing. For impermeable finishes plasticized polyvinyl chloride, 'Igelit', was largely used, as well as emulsion coatings of polyvinyl acetate, 'Mowilith'. For water-repellent finishes hydrophobic metallic soaps were used extensively, including the proprietary emulsions of waxes and aluminium salts known as 'Ramasits'. No information was collected on the methods employed in bleaching or dyeing jute; but the report includes notes on methods in use for testing paper and textiles, particularly single-fibre testing and mechanical devices for estimating the evenness of yarns.

The Textile Institute

CO-OPERATION between textile technologists in Great Britain and the United States has been strengthened by the formation of a panel of American technologists in New York, which consists of eight leading American men of science, of whom Mr. R. J. Kerr-Muir, president of Lustre Fibres, Inc., is the chairman. The panel is intended to provide general liaison between the Textile Institute, which is the official international organisation of textile technologists, and technologists in the United States; and it is hoped that by an exchange of British and American ideas on textile education, reciprocal visits of teaching staff, a wider distribution in the United States of the *Journal of the Textile Institute* and by collaboration with publishers of similar scientific journals in America, a general advancement of technological knowledge will result throughout the whole industry. There are at present some 130 members of the Textile Institute in the United States, including more than twenty fellows and five associates. Two hundred organisations also subscribe to the *Journal*.

A new Section of the Textile Institute has been formed to serve the South Wales and Monmouthshire area, which has recently been entered by various branches of the textile industry. An inaugural meeting will be held at the South Wales Institute of Engineers, Park Place, Cardiff, on April 4 at 7.30 p.m., when the president of the Institute, Mr. J. Foster Beaver, will speak on "The Textile Institute, Its Aims and Objectives". The new Section brings the total number of sections of the Textile Institute to fourteen.

Radio Communication and the Upper Atmosphere

THE Department of Scientific and Industrial Research has recently issued a report by Sir Edward Appleton and Dr. W. J. G. Beynon entitled "Radio Research. Special Report No. 18: The Application of Ionospheric Data to Radio Communication" (London: H.M. Stationery Office, 1948; 1*s*. net). This publication comprises a reprint in a single booklet of two papers published by the authors in the *Proceedings of the Physical Society* in 1940 and 1947 together with material taken from confidential reports circulated during the War and now published for the first time. A large portion of the report is of

a theoretical nature, and shows how radio waves which strike at various angles the reflecting layers of the upper atmosphere, situated at heights of 100–400 km., are bent so as to arrive back at the earth's surface at distances which may be hundreds or even thousands of kilometres from the sending station. The results of such calculations are presented in a number of graphs, which indicate to the radio engineer the best wave-length or frequency to use when he desires to transmit a message or programme to a given distance in a particular direction. By sending up radio waves vertically into these reflecting layers, or the ionosphere as it is termed, and by studying the reflexions on their return to earth, one can deduce the properties of these layers and the manner in which they change from day to night, season to season and year to year. Thus by making local measurements in different parts of the world, the practical radio engineer can assess the effectiveness of his sending stations and the range at which adequate signals will be received at various times or seasons. The later sections of the report refer briefly to some experiments, to be described in more detail elsewhere, which have been successfully made to check the accuracy of the theoretical analysis. The work described in the report forms the basis for the design and operation of many of the radio-communication and broadcasting services in use to-day.

Feeding Organs of Arachnida

Under the foregoing title, Dr. R. E. Snodgrass, of the U.S. Bureau of Entomology and Plant Quarantine, contributes a comprehensive memoir on the mouth-parts and associated structures as displayed in the main divisions of the Arachnida, including mites and ticks (*Smithsonian Mis. Coll.*, **110**, No. 10, pp. 93+29 figures; 1948). The Arachnida are believed to have been evolved from an ancestral stock that never acquired jaws for mastication—a feature that marks them off from all other living arthropods. Their most characteristic mouth appendages are the cheliceræ, and the possession of these organs forced the ancestral arachnids to feed upon such liquids as they could extract from their prey. The latter are caught by the cheliceræ or by means of the pedipalpi, should the latter appendages be chelate. The prey is held by the cheliceræ while its body fluids are imbibed because, unlike insects, arachnids have no organs for mastication. Some arachnids practise external digestion, the solvent fluid probably being a product of the salivary glands in some cases and of the enteric diverticula in others. Students of zoology, and particularly those concerned with the Arthropoda, will find in this memoir an admirably clear and well-illustrated account of a subject that seldom meets with adequate treatment in text-books. Beginning with a general discussion of the structure of arachnid feeding organs, the author then goes on to deal with these parts in greater detail in the different orders. The Palpigradi come first for discussion and are followed by the Solpugida, and the memoir concludes with the very diverse assemblage that is included in the Acarina. At the end there is a useful bibliography of the leading papers in the field under consideration.

Royal Anthropological Institute: Ancient Mining and Metallurgy Committee

Shortly after the end of the War, the Royal Anthropological Institute formed a Committee, with representatives of various branches of science concerned, to investigate problems of ancient mining and metallurgy. This Committee is prepared to advise excavators concerning the technology of metal tools and other artefacts, and in certain cases to carry out complete analyses of such material. One of the most crucial problems in study of the development of technology and applied science is the extent to which native copper was used in prehistoric times, and how far the discoveries of its properties of malleability and fusibility preceded that of the art of extracting copper from its ores. It is generally admitted that native copper was used before smelted copper. Indeed, one school holds that early metal-using cultures were dependent upon native copper for a considerable time, so that there would be two phases in intelligent metallurgy (apart from a supposedly still earlier phase in which, as in pre-Columbian North America, copper was worked cold as a superior kind of stone). Data are badly needed to determine how far cultures using only native copper preceded those using the smelted copper; but this is bound up with a further problem, namely, the best method of distinguishing the native copper from the metal from oxidized ore. The Committee has started to investigate the problem and has issued a preliminary report (see *Man*, Art. 3 and 17; 1948). In order to make further progress, a large body of material must be examined, and therefore archæologists are asked to advise the secretary of the Committee (Miss S. Benton, c/o Royal Anthropological Institute, 21 Bedford Square, London, W.C.1) of material from early cultures of which they have knowledge, or which they could send for examination and report.

Extra-mural Activities in Sheffield

Probably the most interesting account in the first annual report of the Director of Extra-mural Studies to the University of Sheffield is the way in which lecture courses and single 'popular' lectures have been built up. At one time these were given regularly at the University and attracted large audiences. Of recent years few lectures and courses have been given; but the work of the newly constituted Extra-mural Department during the last session has shown that there is in, and around, Sheffield a large and varied public interested in what the University has to offer. This was strikingly demonstrated when Prof. N. B. Namier delivered the opening lecture of a course on "The Year of Revolutions, 1848". More than two hundred people attended and a further hundred had to be turned away. Another interesting feature of the year's work has been the arranging of three special courses indicating the part an extra-mural department can play in extending the influence of the University in the locality outside its walls. The first was for German prisoners of war in north-east England, the second for graduates of the University and meant to be of a 'refresher' nature, and the third, arranged at the request of the Ministry of Labour, for hospital matrons.

International Society of Soil Mechanics and Foundation Engineering

At the Second International Conference on Soil Mechanics and Foundation Engineering held at Rotterdam in June 1948, a Society was established for promoting international co-operation in the sphere of soil mechanics and its practical applications. This Society proposes to encourage the interchange

of knowledge and of results of research and practical experience by organising conferences and publishing annual reports reviewing the development of soil mechanics which each country has made during the year. The statutes of the Society provide for a number of national organisations, and the British Section of the Society has now been formed and is administered by the British National Committee. Membership is open to all interested in soil mechanics and its applications. There is a registration fee of £2, and the annual subscription is 10*s*. Full particulars can be obtained from the Secretary to the British National Committee at the Institution of Civil Engineers, Great George Street, London, S.W.1.

Science Masters' Association (Scottish Branch): Meeting in St. Andrews

DURING April 12–14 the annual general meeting of the Scottish Branch of the Science Masters' Association will be held in St. Leonard's School, St. Andrews. Sir James Colquhoun Irvine, principal and vice-chancellor of the University of St. Andrews, will preside at the meeting. The programme for the three days is very full and consists mainly of scientific lectures, exhibitions, and visits and excursions. This branch of the Association was formed in January 1947, and the first annual general meeting was held at the University of Glasgow in April 1948. The organising secretary for the St. Andrews meeting is Mr. F. G. Daldy, of Trinity College, Glenalmond, and Mr. Daldy and Mr. J. Wallace, of Melville College, Edinburgh, are joint secretaries of the Scottish Branch.

Publication of Scientific Papers

AT the Scientific Information Conference held last year, the Royal Society was invited to approach printing organisations with the view of setting up permanent relations for maintaining understanding and co-operation with scientific publishing bodies. It is proposed to arrange a meeting shortly to discuss the current position with regard to scientific publishing and printing. The Royal Society will be glad to receive any statement of difficulties and suggestions for discussion. Comments should be addressed to the Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1.

Publication Difficulties of American Physics Journals

IN the February issue of *Physics Today*, it is mentioned that within a few months many of the American physics journals would appear with reduced margins and with less space between the lines. By this means, without altering the page size, it is hoped to add twenty per cent to the content of each page, and thus, by saving in press work and paper, to meet the cost of publication despite the fact that costs and the volume of contributed material are rising faster than income. Another suggestion, which may yet have to be put into practice, is to use a more compact type-face. For the *Journal of Chemical Physics*, figures are quoted which show that there has been a steady rise in the number of printed pages, from about 600 in 1944 to 1,250 in 1948, with, in addition, a steady rise in the cost of production per page. It is estimated that 2,000 pages will be required in 1949. This is not confined to the *Journal of Chemical Physics*, but is typical of the other journals published by the American Institute of Physics; and the executive committee of the Institute has been contemplating some form of restriction on publication. Neither increased advertising income nor increases in subscriptions are considered to be a solution, and readers of the journals are asked to give their views and suggestions as to methods to meet the present serious situation.

Announcements

THE Council of the Linnean Society of London has awarded the Linnean Medal for the year 1949 to Prof. D. M. S. Watson, Jodrell professor of zoology and comparative anatomy at University College, London. Linnean Medals have also been awarded to Dr. W. T. Calman, lately keeper of zoology in the British Museum (Natural History), and Prof. F. E. Weiss, emeritus professor of botany in the University of Manchester, in respect of the war years during which no awards were made.

THE first meeting of the United Kingdom National Commission for Unesco is to be held at Church House, Westminster, on April 11 at 10.15 a.m. The National Commission consists of about 250 members representing important organisations in the fields of education, science and culture. Mr. George Tomlinson, Minister of Education, will be in the chair, and among the speakers will be Dr. Torres Bodet, director-general of Unesco. Morning and afternoon sessions will deal with the work of Unesco.

A MEETING of the European Hæmatological Society will be held in Montreux (Switzerland) during September 15–17, 1949, to discuss hæmolytic anæmias, and variations of blood proteins in blood dyscrasias. Further information can be obtained from Dr. A. Piney, 152 Harley Street, London, W.1.

A GENERAL constituent assembly for the foundation of the Permanent Council for the Co-ordination of International Congresses of Medical Sciences will be held in the Palais des Académies, rue de la Loi, Brussels, during April 4–9. This conference is sponsored jointly by the United Nations Educational, Scientific and Cultural Organisation and the World Health Organisation at 141 rue Belliard, Brussels.

THE Central Council for Health Education will hold its 1949 residential Summer School in Health Education at the School of Domestic Economy, Eastbourne, during July 28–August 11, under the direction of Dr. Robert Sutherland. The school will be of interest to all concerned with health education and should be of special value to medical men, teachers, public health nurses, industrial nurses, industrial welfare workers, social workers, etc. Further information can be obtained from the Medical Adviser and Secretary, Central Council for Health Education, Tavistock House, Tavistock Square, London, W.C.1.

THE Development Commissioners, in association with the Ministry of Agriculture and Fisheries and the Scottish Home Department, offer postgraduate training grants of £220–300 per year, tenable from October 1, 1949, for training men and women in the investigation of problems in marine and freshwater science. The grants (about five in number) are open to honours graduates in science of a British university, and are tenable for one year with renewal up to a maximum of three years. Forms of application (to be returned by May 1) and full details may be obtained from the Secretary, Development Commission, 6*a* Dean's Yard, Westminster, London, S.W.1.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Production of Mesons by Electrons

In view of recent developments in the design of accelerators for the production of high-energy electrons, it is desirable to investigate the probability of producing mesons by electron bombardment.

(1) The simplest process of this type is:

Electron + proton → electron + neutron + positive meson.

The production of mesons in this way bears a close resemblance to the production of quanta in radiation processes. It results from the mutual interaction of electrons and protons with the radiation field and the meson field. In analogy with radiation processes, we can decompose this process into two elementary processes, the first of which corresponds to the electrostatic scattering of the electron by the proton, and the second of which leads to the production of a meson:

$$e + P \rightarrow e' + P' \rightarrow e' + N + \pi^+.$$

It should be noted that from the point of view of perturbation theory the first of these processes is a second-order process. It is found that so long as we restrict ourselves to energies for which the proton recoil is negligible (that is, to energies small compared with 940 MeV.) we may neglect the effect of retardation, which would appear in the representation of the electric scattering as the emission and absorption of light-quanta by electron and proton. With this restriction we may also neglect the small interaction terms of Yukawa's theory.

The total cross-section for the production of a vector-meson comes out to be

$$\frac{3}{\pi}\left(\frac{1}{137}\right)^3 \frac{g^2}{\hbar c}\,\lambda_\mu{}^2\, I\,(E),$$

where λ_μ is the Compton wave-length of the meson; g is the interaction constant of the Yukawa theory ('meson-charge'); E is the energy of the electron with the rest-mass of the meson as a unit; and $I(E)$ is given by

E	1·25	1·5	2·0	4·0	10
$10\ I(E)$	2·4	21	200	2000	(7400)

The last figure is put in brackets because the energy to which it belongs is outside the region in which the proton recoil is negligible.

For electrons of energy ~ 300 MeV., this gives a cross-section of the order 10^{-33} cm.^{2}.

(2) Another possible process is

Electron + neutron → electron + proton + negative meson.

Decomposing this process into elementary processes, we have to consider that the neutron first emits a negative meson and that the electron is then scattered inelastically by the resulting proton. The result is the same as under (1); but a small correction factor (> 1) due to the electrostatic interaction between the meson and the proton has to be added.

(3) These cross-sections are so small that it is worth while considering whether or not larger cross-sections can be obtained by bombarding nuclei other than hydrogen by electrons. By analogy with *Bremsstrahlung* we might expect the cross-section for an atom with charge Z to be larger by a factor Z. It turns out that this factor is approximately correct, but its establishment by this analogy is incorrect, since for any nucleus a competing intermediate state occurs:

$$e + (Z) \rightarrow e' + (Z)' \rightarrow (Z-1) + e' + \pi^+,$$
$$e + (Z) \rightarrow e + (Z-1) + \pi^+$$

Neglecting recoil, the energy denominators in the two branches of the process are equal but opposite in sign; the matrix elements corresponding to the Coulomb scattering of the electron differ only in that in the second branch the electron is scattered by the nuclear charge $Z - 1$, whereas in the first branch it is scattered by the charge Z. However, since the nucleus $(Z - 1)$ can be left in a large number of excited states, the energies of which differ only by small amounts (compared with the meson mass), we obtain a factor of the order:

$$\begin{matrix} AZ & \text{for positive mesons} \\ A(A-Z) & \text{for negative mesons,} \end{matrix}$$

which, multiplying the cross-sections for proton- and neutron-cases respectively, gives the cross-sections for the nuclear process. Furthermore, in the case of heavy atoms and moderate meson energies a Gamow factor expressing the effect of the nuclear charge on the mesons has to be taken into account. This factor favours the production of negative rather than positive mesons.

In the case of heavy nuclei, the factor multiplying the one-particle cross-section may be of the order 10^4, so that the cross-section for the production of mesons by the bombardment of a heavy nucleus with 300-MeV. electrons is of the order 10^{-29} cm.^{2}.

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Oct. 7.

Decay of Holmium-166

When the element holmium is irradiated with slow neutrons the radioactive isotope holmium-166 is produced. This decays by β-emission to the stable isotope of erbium, Er^{166}.

The decay of holmium-166 has been investigated by several observers, the most recent work being that of Bothe[1], who gave the value of $27{\cdot}3 \pm 0{\cdot}5$ hr. for the half life-time; and, using absorption methods,

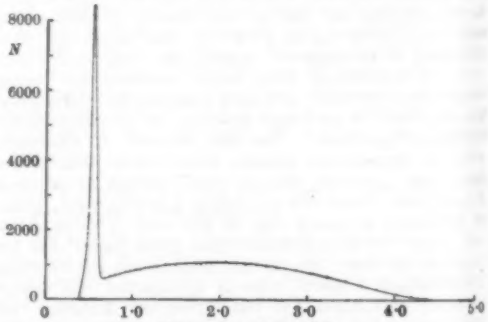

Fig. 1

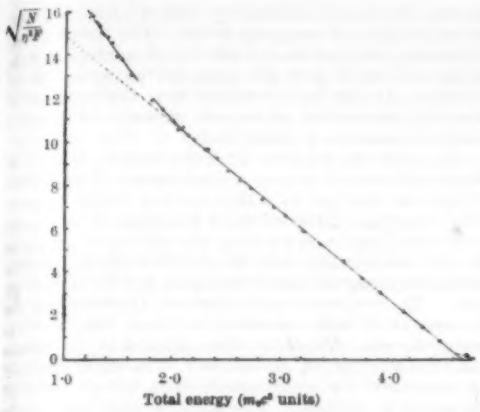

Fig. 2

obtained the value of the maximum energy of the β-spectrum of 1·8 MeV. In the present experiments, we have investigated the decay by means of a short magnetic lens β-ray spectrometer, and by coincidence and absorption methods.

Measurement of the half life-time over a period of 14 half life-times gave the value of 26·8 ± 0·4 hr., this being in agreement with Bothe's result within the limits of experimental error.

The distribution in momentum of the β-particles is shown in Fig. 1, and a Fermi plot of this spectrum is shown in Fig. 2. This Fermi plot indicates the maximum energy of the β-spectrum to be 1·88 ± 0·02 MeV. In addition to the continuous β-spectrum, a single-conversion electron group was found having an energy of 70·5 ± 0·7 keV. This is thought to be due to the conversion of a γ-ray of 80·2 ± 0·7 keV. in the L-shell of the daughter nucleus. The window of the counter on the spectrometer had a thickness of 1·8 mgm. cm.$^{-2}$, and this would not transmit the K-conversion electrons of a γ-ray of this energy. Absorption of the γ-radiation in lead and in brass gave results that were consistent with this interpretation.

The absorption of the γ-radiation in lead showed that in addition to the γ-radiation of 80 keV. there was present γ-radiation of energy 1·2 ± 0·1 MeV. This harder γ-radiation is of fairly low intensity, measurement of which by means of a calibrated γ-counter indicated that a quantum was emitted in about 1·5 per cent of the β-disintegrations.

From Fig. 1 the ratio of conversion electrons to β-particles is estimated as 23 ± 1 per cent. The window of the Geiger counter will, however, have an appreciable stopping power at this energy, and the correct figure will be nearer 30 per cent.

Although the K-conversion electrons could not be detected on the β-ray spectrometer, the amount of the conversion was estimated from the intensity of the K-radiation emitted from the source. This K-conversion appeared to be considerably lower than the conversion in the L-shell, and the ratio of K-conversion electrons to β-particles is probably only of the order of 10 per cent.

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Oct. 6.

[1] Bothe, W., *Z. Naturforsch.*, 1, 179 (1946).

Distortion-free Electrostatic Lenses

The problem of correcting the aberrations inherent in electron lenses is of major importance particularly in the field of the electron microscope, where they set a limit to the resolving power. It is well known that the predominant form of distortion with electrostatic lenses (immersion objective, etc.) is of the pincushion or barrel type. The early type of image tube developed by Ramberg and Morton[1] gave a pattern which suffered from the former type. This was corrected by the expedient of using a curved cathode, that is, by an alteration in the form of the field, and indeed it appears from the work of Voit[2] that this form of error is removable if the field conditions are correctly chosen.

An investigation of the degree of distortion present in symmetrical lenses of the three-aperture type (radius 2 mm., separation 4 mm.) was undertaken here with a view to their incorporation as electron microscope elements. It was soon confirmed, using a fine mesh on the object side, that the distortion took either of the above forms.

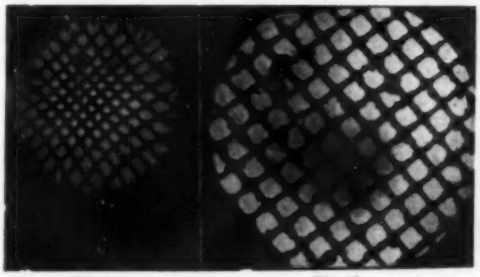
Fig. 1*a* Fig. 1*b*

Fig. 1*a* shows the pronounced pincushion effects obtained when the electrodes were thin (that is, thickness to spacing ratio less than ¼). The distortion when measured up from the paraxial Gaussian image can be expressed by a cubic law as in optics; the change of magnification with height consequently follows a square law, namely, $M_h = M_0\ (1 + kh^2)$, where M_0 is the paraxial magnification, h the height, while k is a constant of value about 0·2. This form of law also holds for the 'barrel' type of distortion when it is present. As a consequence, it appears that both the principal and focal planes have a parabolic form. Liebmann[3] has found this to be so. The difference between the two, which is the quantity measured, thus conforms to a square law. This relation appears to hold for values of h up to at least one fourth the value of the aperture radius r, and often up to 0·5 r.

If, however, the thickness T of the central electrode is increased, the extent of the distortion decreases, and for $T/D = 0{\cdot}75$ and $s \simeq D$ disappears entirely when connected for the 'Einzel' condition.

Fig. 1*b* shows the improvement, and Fig. 2 the relation between the distortion and the ratio of thickness T to diameter D for various values of separation s. For ratios above the optimum correcting value, the barrel effect becomes noticeable, so that the distortion has become over-corrected, and the focal length now falls inside the lens field. The transition between the two types of distortion can be followed as the strength of the lens is varied, and there seems grounds for believing that, with further

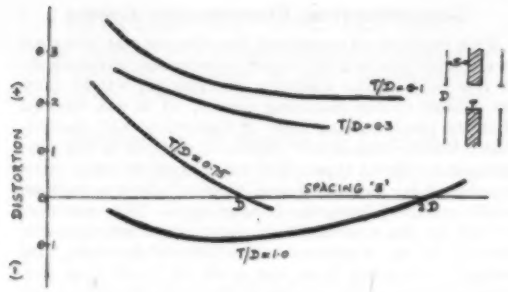

Fig. 2

increasing strength, there is a return to the original type of distortion, indicating that the electrons cross the axis twice on their way to the screen.

An effect of a similar kind occurs with a magnetic projection lens and can be readily demonstrated. The 'pincushion' pattern becomes less distorted with increasing lens-strength, and for one particular value of lens-power no distortion is present. With further increase in strength the magnification decreases and 'barrel' distortion appears; this later gives place to bad 'pincushion' effects with increasing rise in lens power.

It is interesting to note that the effect produced by introducing the thick middle electrode is the same as that shown by Hillier[4] to hold for a combination of two lenses of approximating equal focal length separated by a distance equal to their focal length.

The screening effect of the thick central electrode appears to produce a lens on either side of it, which, in combination, eliminate the distortion.

It is hoped to publish these results in full at a later date.

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George Holt Physics Laboratories,
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[1] *Physics*, **7**, 451 (1936).
[2] *E. Instr.*, **59**, 71 (1939).
[3] *Proc. Phys. Soc.* (in the press).
[4] *J. Appl. Phys.*, **17**, 411 (1946).

Stopping Power of Liquid Water for α-Particles

The mean stopping power of liquid water averaged over the whole range has been determined for natural α-particles by Michl[1] and by Philipp[2]. These authors find values for the molecular stopping power which are higher by about 20 and 14 per cent respectively than those predicted by the Bragg law and the accepted atomic stopping powers of hydrogen and oxygen. Philipp (*loc. cit.*) has also shown that the stopping power of water vapour accords with the Bragg law. The tendency among physicists has, however, been to treat the Bragg law as a more reliable guide to the stopping power of liquid water than the experiments.

Water occupies a fundamental position in radiobiology as the most important constituent of all living cells. Any uncertainty as to its stopping power is, in consequence, most undesirable, especially from the point of view of practical dosimetry and radiotherapeutics. Experiments have therefore been carried out in this laboratory with a view to the redetermination of stopping power. The method used differs in principle from both the photographic technique of Michl and the microscopic technique of Philipp. It has the advantage that the necessity of locating the surface of a layer of water to within a very few microns is eliminated.

An aqueous solution of polonium in 0·5–1·5 *N* hydrochloric acid acts as a thick source of α-particles which are detected by a thin-window Geiger counter. The variation of the effective thickness of the source with the distance in air from the surface of the liquid to the counter may then be used to measure the ratio of the stopping powers of the liquid and the laboratory air. To determine the effective thickness of the source, it is only necessary to know the counting-rate, the area of liquid surface exposed to the counter and the strength of the solution. The latter quantity is measured by evaporation of a known mass of solution to dryness. The counting-rate due to the dried source is then compared with that due to the solution under similar geometrical conditions.

Preliminary results indicate that for 4–5 MeV. α-particles the instantaneous stopping power per molecule of liquid water relative to that of air per atom is 1·71. The experimental error of the determination is estimated to be less than ± 5 per cent. This value is approximately 13 per cent higher than the value, 1·51, predicted by the Bragg law. On the basis of the Bethe–Bloch theory, it agrees within experimental error with the mean stopping powers obtained by Michl and by Philipp. This suggests that the higher value of the stopping power of water should be used in the assessment of the radiotherapeutic effects of heavy particles.

A detailed description of these experiments will be published elsewhere.

The assistance of a grant from the Medical Research Council is gratefully acknowledged.

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Oct. 1.

Michl, W., *Sitz. K. Akad. Wiss. Wien*, **123** (IIA), 1965 (1914).
Philipp, K., *Z. Phys.*, **17**, 23 (1923).

Methylene Bromide as a Quenching Agent in Geiger–Müller Counters

Geiger–Müller counters filled with methylene bromide and argon are known[1] to be self-quenching and to possess long sloping plateaux. Measurements have now been made of the β-counting-rate as a collimated source was moved diametrically across the mica end-window of a β-ray counter so that β-particles entered the counter parallel to the centre wire. Two counters *A* and *B* of identical construction were used for these measurements, *A* containing argon at a pressure of 97 mm. of mercury and ethyl alcohol at a pressure of 9·7 mm. of mercury, and *B* containing argon at a pressure of 74 mm. of mercury and methylene bromide at a pressure of 7·4 mm. of mercury. It was found that the efficiency of counter *B* was greatest for particles entering the counter near the centre wire, but even then was less than that of counter *A* by a factor of about three.

The usual method[2] for calculating the theoretical efficiency of β-ray counters assumes that, in order to cause a count, only one electron need be produced in the counter by a β-particle. According to this

theory, both counters A and B should be nearly 100 per cent efficient. We suggest that the observed lower efficiency of counter B is due to the formation, by attachment, of negative ions in methylene bromide. This hypothesis would also explain the large plateau slope of this counter. Assuming, to a first approximation, that none of the negative ions causes counts, it can be shown that the coefficient of electron attachment α is given by

$$\alpha = \frac{d\gamma_r}{dr} / \{(1 - \gamma_r) \log (1 - \gamma_r)\},$$

where γ_r is the ratio of the efficiency of counter B to that of counter A for β-particles entering the counter at a distance r from the centre wire.

By means of this equation, using the measured values of γ_r, α/p has been calculated as a function of Z/p, where p is the partial pressure in mm. of mercury of the methylene bromide in the counter, and Z is the field-strength in volts/cm. The results obtained are of the same order of magnitude as those obtained for bromine by means of the diffusion method developed by V. A. Bailey[3]. This lends some support to the hypothesis adopted to explain the low efficiency of counter B.

Further measurements are being made using counters containing other gas mixtures. A more detailed account of this work will be published later.

In conclusion, we wish to thank Prof. V. A. Bailey and Dr. R. E. B. Makinson for their interest and advice, and to acknowledge the receipt of a Commonwealth Research Grant from the Research Committee of this University.

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Department of Physics,
University of Sydney.
Sept. 23.

[1] Mateosian, E. der, and Friedman, H., *Phys. Rev.*, **69**, 689 (A) (1946).
[2] Korff, "Electron and Nuclear Counters" (D. van Nostrand Co., New York; Macmillan, London, 1946).
[3] Bailey, J. E., Makinson, R. E. B., and Somerville, J. M., *Phil. Mag.*, **24**, 177 (1937).

Vaporization of Titanium

The rate of evaporation of titanium wires *in vacuo* has been measured over the temperature-range 1,650–1,800° K. The results can be expressed as

$$\log_{10} ET^{1/2} = \frac{-2{\cdot}07 \times 10^4}{T} + 7{\cdot}70,$$

where E is expressed in gm. cm.$^{-2}$ sec.$^{-1}$.

It follows thermodynamically that the latent heat of vaporization in this temperature-range is 95 k.cal. per mole. This value is unlikely to be in error by more than 5 per cent.

In the course of the work the variation of total radiation with temperature was incidentally determined, and found to be proportional to $T^{4\cdot4}$, the emissivity at 1,700° K. being about 30 per cent of that of a black body.

The work is being continued.

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Aug. 23.

Shape Factor in Particle-Size Measurement

We have had occasion to separate alumina powder into uniformly sized groups for testing fuel filters, and to measure the particle-size microscopically. It seemed likely that a measurement of a linear dimension together with a factor describing the shape of the particles would be the most useful parameters to correlate with filter performance, since whether a particle will pass through the filter apertures will depend upon both size and shape. It was accordingly decided to use Feret's statistical diameter[1].

The degree of uniformity of the powder is derived from the coefficient of variation K, obtained by dividing the standard deviation by the mean of the diameters. K is made up of the desired coefficient of variation K_1 due to scatter in size, and K_2 due to deviation from spherical shape, which makes the measured diameter depend on the orientation.

K_2 varies from zero for particles of circular profile to 0·484 for needle-like particles. A value for K_2 is obtained by measuring the diameter of a number of particles in four orientations, spaced at intervals of 45°. The four diameters of each particle are divided by their mean. K is then the standard deviation from unity of all the quantities obtained in this way. Use of K_2, once obtained for a given type of particle, enables the variation in size to be determined from the relation

$$K^2 = K_1^2 + K_2^2.$$

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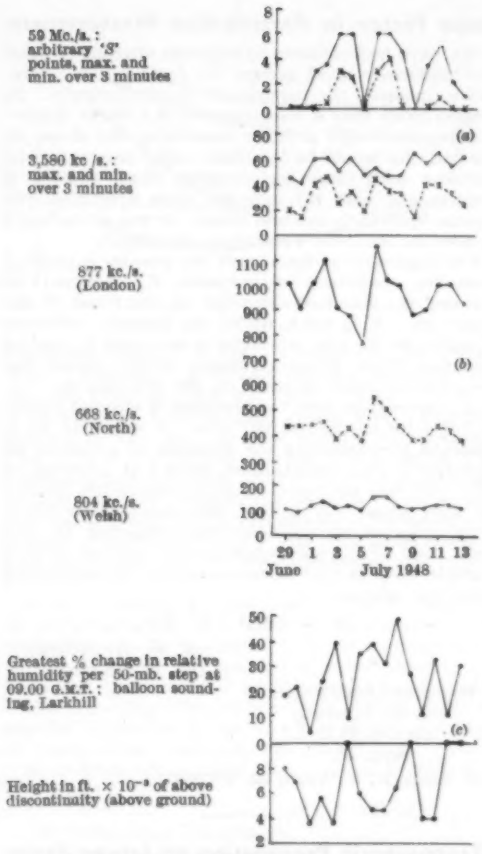
[1] See Walton, W. H., *Nature*, **162**, 329 (1948).

Tropospheric Propagation on Lower Radio Frequencies

In recent years the subject of tropospheric propagation of the very high radio frequencies has received considerable attention, but very little work appears to have been done at other parts of the radio spectrum; generally, in fact, the effect is referred to as occurring 'over 30 Mc./s.'. This is no doubt largely due to the over-riding effect of ionospheric propagation on the lower frequencies. Recent tests, of a qualitative nature, which I have made, however, suggest that tropospheric effects should not be ignored, even on frequencies below 1,000 kc./s.

My attention was first directed to this fact during some tests at 59 Mc./s. between my amateur station (*G6DH*) at Clacton-on-Sea, Essex, and that of Mr. E. Early (*F8ZF*) at Boulogne-sur-Mer, a distance of some ninety miles, almost entirely over sea water. In these tests a frequency of approximately 3·6 Mc./s. was used for communication purposes. It was observed that on days when the 59 Mc./s. signal was of good strength (under the meteorological conditions now easily recognized as being suitable for this form of propagation) the general level of the 3·6 Mc./s. signal was also higher than on a day when tropospheric conditions were 'poor'.

Unfortunately, automatic recorders were not available; but the results obtained were sufficient to show an undoubted correlation between the 3·6 and 59 Mc./s. signals and meteorological conditions, as the


59 Mc./s.: arbitrary 'S' points, max. and min. over 3 minutes
3,580 kc./s.: max. and min. over 3 minutes
(a)
877 kc./s. (London)
668 kc./s. (North)
804 kc./s. (Welsh)
(b)
29 1 3 5 7 9 11 13
June July 1948
Greatest % change in relative humidity per 50-mb. step at 09.00 G.M.T.: balloon sounding, Larkhill
Height in ft. × 10⁻³ of above discontinuity (above ground)
(c)

(*a*) and (*b*). Signal strength records (in μV.) at 07.15–07.30 G.M.T. of various stations received at *G6DH*, Clacton, Essex, July 1948. (*c*) Records from Upper Air Section Daily Weather Report, Meteorological Office. (Owing to time difference and difference of location, exact correlation would not be expected)

accompanying extracts from the records will confirm (*a*) and (*c*).

In view of these results on 3·6 Mc./s., it was decided to check the effects observed on still lower-frequency medium-wave broadcast stations at the same time daily, approximately 07.30 G.M.T. Those stations observed were the London 877 kc./s., 70 miles west-south-west; North 668 kc./s., 220 miles north-north-west; and Welsh 804 kc./s., 210 miles west of my station. Here again correlation with meteorological conditions was observed (*b*) and (*c*). In the case of these lower frequencies, short-period fading as observed on 3·6 Mc./s. was almost non-existent, and during the daily three-minute checks, only a general increase or decrease in the signal strength compared with the previous day, or days, would be noted.

In general, it could be said that, under anticyclonic weather conditions, increases above the average signal-strength of the order of 25 per cent in the case of the nearer London station, 33 per cent Welsh and 40 per cent North were observed. Similarly, with turbulent unsettled weather, corresponding drops in signal-level were noted. A given weather system would not, of course, affect all frequencies, distances and directions in the same manner, the field-strength of any particular station being the result of waves arriving over more than one path. It should, perhaps, be stated that reference to British ionosphere sounding records for the period under observation—May to September 1948—did not account for the variations noted.

Limitations of time and available apparatus have prevented further work on the subject, but it would appear to be an interesting field for further research for those more fully equipped.

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Measurement of Sporadic *E*-Layer Ionization

The usual measure of sporadic *E*-layer ionization is the so-called 'critical frequency', that is, the highest reflected frequency for this layer. While this definition is suitable for all other ionospheric layers, it is not sufficient for the sporadic *E*-layer (*Es*), because it consists of ionized clouds and has no homogeneous ionization. Partial reflexion is a normal phenomenon for this layer.

In the usual ionospheric pulse-measurement the working frequency is varied over a large band of short waves. If sporadic ionization is present, reflexion from the *Es*-layer will be total for low frequencies generally, but the reflexion coefficient decreases with increasing frequency. There are cases where partial reflexion occurs in a large band (echoes from the *Es*-layer and from the *F*-layer are observed at the same time). Finally, if the working frequency has become sufficiently high, *Es*-reflexions cease and only *F*-echoes are present. This slow variation of the reflexion coefficient does not occur with normal ionospheric layers.

The highest frequency which gives observable echoes from the *Es*-layer depends strictly on the output of the pulse transmitter and on the properties of the receiver. With a high-power transmitter, even faint reflexions from the *Es*-layer will be observed, and a higher value will be obtained for the 'critical frequency' than with a normal transmitter. In most ionospheric equipment, radiated power varies considerably with frequency, and it is not impossible that statistics of measured 'critical frequencies' reproduce essentially the properties of the equipment. Measurements made on different stations cannot be compared without taking great precautions.

A more accurate measure of *Es*-ionization should take account of the variation of the reflexion coefficient with frequency. Therefore it is proposed to compare the amplitudes of echoes reflected from the *Es*- and *F*-layers. A practical method is described below, which has been elaborated at the ionospheric station of the Service Ionosphérique de la Marine Française at Freiburg. This method includes the use of a special pulse receiver, the curve of gain of which has a nearly logarithmic shape. In combination with the normal ionospheric measurement (working frequencies varying from low to high frequencies) the amplitudes of the echoes are observed on the graduated screen of a cathode ray tube. The amplitudes of *Es*- and *F*-reflexion are compared with each other, and five frequencies are noted with respect to the ratio of these amplitudes. These ratios are:

100 : 1, 10 : 1, 1 : 1, 1 : 10, and 1 : 100, that is, in steps of 20 decibels, and these frequencies are denoted as : fEs (−2), fEs (−1), fEs (0), fEs (+1), fEs (+2).

Absorption influence in the D-layer can be supposed to be equal for both paths (on one frequency). But there will be a difference in field-strength, because the path-length up and down is different for reflexion from Es and F. The ratio of heights $h'F/h'E$ is approximately 2·5 (8 decibels). Comparisons being made for field-strength measured at ground, their ratio can easily be deduced from the assumption that there is no loss of energy in the Es-layer (by selective absorption or by diffusion). If e denotes the 'reflexion coefficient' (for amplitudes) of the Es layer, $\sqrt{1-e^2}$ is the coefficient of transmission. Now the relative amplitudes at ground-level are :

$\frac{e}{h'E}$ for E_s-reflexion and $\frac{\sqrt{1-e^2} \times \sqrt{1-e^2}}{h'F}$ for F-reflexion.

In consequence, the ratio ρ of measured field-strength is :

$$\rho = \frac{e \,.\, h'F}{(1-e^2) \,.\, h'E} \approx 2{\cdot}5 \times \frac{e}{1-e^2}.$$

The values of ρ, chosen for convenience in a decadic system, will correspond to the following coefficients of reflexion :

ρ	=	100	10	1	0·1	0·01
e	=	98·8	88	35	4	0·4 per cent

(By changing the ρ-scale a simpler e-scale could be obtained. But the above-mentioned scale has the advantage of giving equal differences of amplitudes for a receiver with logarithmic curve of gain.)

The advantage of this method is illustrated by the results of measurements taken since July 1948 at Freiburg. During August about 450 measurements were made, that is, about 19 measurements for each hour of the day. Fig. 1 gives the resulting median values. There are considerable differences which cannot be neglected for prediction work. The so-called 'Es critical frequency' is for our station a value between fEs (+1) and fEs (+2); the figure shows that there is a considerable influence of equipment data on 'critical frequency'. The coefficient of reflexion of the Es-layer near its 'critical frequency' is only about 1 per cent. Mass-plots show increasing dispersion of points with decreasing coefficient of reflexion. The lowest frequency for which F-reflexion is obtained, called fA, is more precisely defined than fEs.

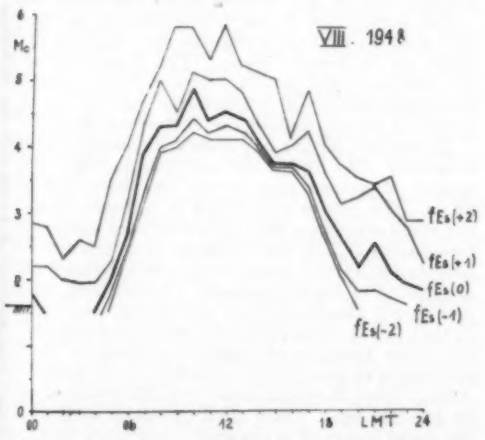

Fig. 1

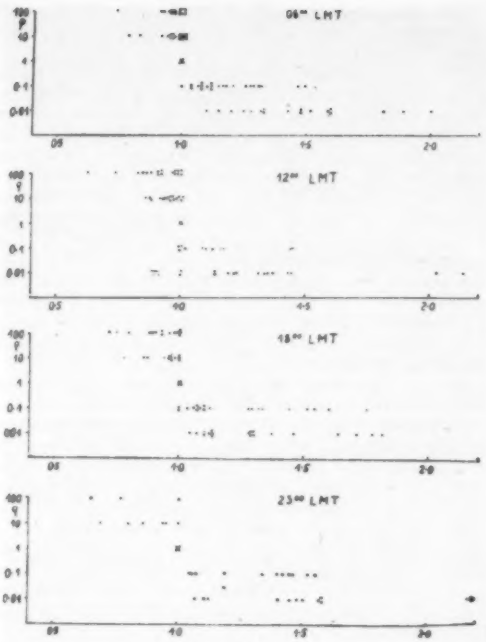

Fig. 2

Quite different observations have been made. Sometimes ionization is rather homogeneous and our five frequencies are close together; sometimes differences are very large. This is demonstrated by Fig. 2, where reduced values (divided throughout by fEs (0)) have been used. Thus the relative variation of the coefficient of reflexion with varying frequency is made visible. Fig. 2 gives mass-plots for different hours of the day, showing that partial reflexion generally covers a large range of frequency, most of which corresponds to a small coefficient of reflexion. This indicates the existence of highly ionized centres in a more or less 'homogeneous' layer. Early in the morning this 'homogeneous' sporadic ionization seems to be small compared with normal E-ionization.

This work forms part of the research programme of the Service Ionosphérique de la Marine Française (SPIM). Measurements are being continued.

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Temperature Coefficient of Sensitivity of Lead Sulphide Photo-conductive Cells at Room Temperature

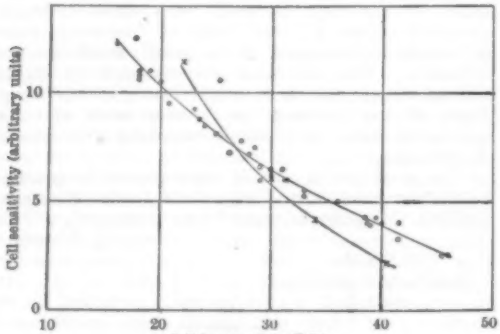
In the course of an investigation being carried out at these laboratories into the possible application of lead sulphide cells to industrial radiation pyrometry, some difficulty was experienced in obtaining stable calibration of an experimental pyrometer due to the apparently high temperature coefficient of sensitivity of the cells. An examination has therefore been made

of the temperature coefficients of some sample cells, 'evaporated' type, in the range of normal ambient temperatures.

The experimental pyrometer made use of the lead sulphide cell as a radiation detector, adopting similar circuit techniques to those used by previous workers. An interrupter disk was used for chopping the radiation falling on the cell at 800 c./sec., the output voltage from the cell bridge circuit being amplified in a homodyne amplifier. The radiant energy falling on the cell was limited by two diaphragms with apertures of 6·5 mm. and 2·5 mm. diameter spaced 35 cm. apart. With this arrangement the sensitivity of the equipment was such that a measurable output was obtained from a black body source at 120° C., which corresponded to an energy irradiating the cell of approximately $1{\cdot}4 \times 10^{-9}$ watt in the wave-length band 1–3 microns.

The experimental technique adopted for measuring the temperature coefficients was as follows. The cell was exposed to a constant-temperature radiation source consisting of a directly heated carbon tube black body furnace (aperture 1 in.) in which a small disk of carbon with embedded thermocouple formed the target. The source temperature was held constant to within 2° during each experiment. The temperature of the cell-sensitive surface was controlled by passing a stream of water of known temperature through the Dewar flask form of cell, the water temperature being measured with a mercury-in-glass thermometer ($\pm$ 0·1° C.).

The cell 'sensitivity' for each temperature of the sensitive surface was recorded in terms of amplifier output signal for a constant source temperature. Since the amplifier had been previously checked for linearity of gain characteristic, its output was directly related to the signal from the cell bridge circuit. The resistance values used in this circuit were such that the cell current was maintained sensibly constant, and thus the figure of sensitivity quoted is, in fact, a measure of the change in cell resistance for a particular change in energy irradiating the cell.



○—○—, Cell 1; ×—×—, cell 2

Measurements were made at cell surface temperatures over a range of 16–46° C. The results are shown in the accompanying graph, which includes seven sets of readings taken on one cell over a period of several days, using a source temperature of 350° C. A further set of readings using a source temperature of 670° C. gave an identical curve relating cell sensitivity and temperature of sensitive surface.

With the source temperatures used the variations of the cell temperatures in the range 16–46° C. have a negligible effect on the radiation exchange between source and receiver.

The graph also shows a similar curve obtained for a second cell which exhibits a somewhat higher temperature coefficient of sensitivity.

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Conversion of Cholesterol to Provitamin D_3 *in vivo*

There is now evidence in the literature that steroid hormones[1] and bile acids[2] are formed from cholesterol. A similar origin for provitamin D_3 (7-dehydrocholesterol) in the animal body, certainly of Herbivora, is now accepted; but there is little or no conclusive evidence as to the site or mode of formation of the provitamin. The part of the body richest in 7-dehydrocholesterol is generally thought to be the skin[3]. Recently, however, we have detected a sterol showing the ultra-violet absorption (max. 271·5 mμ, 281·5 mμ and 292 mμ; inflexion 260–265 mμ and min. 276 mμ) characteristic of the provitamins D, and thought to be provitamin D_3, in the lining of the small intestine of the guinea pig, rat and ox. It is most concentrated in the duodenum and is associated largely with the mucosa and lamina propria. In the guinea pig, the concentration of the '7-dehydrocholesterol' in the non-saponifiable matter of the whole of the small intestine is *c.* 3·6 per cent and is very much greater than the 0·5 per cent observed in the skin; whereas in the rat both organs contain about 0·5 per cent.

This selectively absorbing sterol persisted in the gut-wall, despite fasting the guinea pigs for 24 hr. or placing them on a 'low sterol' diet for fourteen days prior to examination. The 'low sterol' diet was prepared by withholding vegetables and adding 5 per cent groundnut oil (containing *c.* 1·5 per cent non-saponifiable matter spectroscopically free from provitamin D_3) to the solvent-extracted stock diet.

The persistence of the provitamin D_3 in the gut-wall suggests that the substance may function in that organ or be formed there. The formation of the provitamin could be due either: (i) to enzymatic dehydrogenation of cholesterol, or (ii) to total synthesis as postulated[4] for cholesterol itself.

To test the former hypothesis, cholesterol, spectroscopically free from the provitamin, was fed to groups of guinea pigs which had been fasted for 24 hr. The groups were killed at different times and the small intestines and the livers were examined for provitamin D_3. It was observed that the amount of provitamin in the small intestines increased during absorption of the cholesterol. Furthermore, on completing the absorption, the provitamin-level returned to that found in the intestines of control animals. On the other hand, a progressive increase in the concentration of provitamin occurred in the livers. The control livers showed scarcely any selective absorption at 260–295 mμ. These findings make it likely that the sterol observed in the small intestine is 7-dehydro-

cholesterol, and that it is formed there by dehydrogenation of cholesterol.

The quantitative data indicate that only a portion of the cholesterol is dehydrogenated.

Detailed experimental results will be published elsewhere later.

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Pressor Material Prepared from Hæmoglobin

ASSOCIATED with hypertension in the 'Goldblatt animal', the formation of a pressor polypeptide has been demonstrated. It has been shown by Page and Helmer[1] that the action of renin on α_2-globulin produces a histidine-rich polypeptide, angiotonin (see also Edman[2]), which has considerable pressor activity. A peptide having similar activity was obtained by Croxatto and Croxatto[3] by the action of pepsin on α_2-globulin, and this substance, pepsitensin, was shown to be distinct from angiotonin; and Dawson and Findlay[4] have shown the formation of such peptides from hæmoglobin in blackwater fever.

A substance possessing pressor activity has now been obtained in a partially purified form from hæmoglobin by the action of pepsin. The substrate was ox hæmoglobin isolated from fresh defibrinated blood, and the pepsin used was crude B.P. pepsin and highly active material prepared from this by the method of Northrop[5]. The hæmoglobin was suspended in water at *p*H 6 and incubated at 37° for 10 min. with the pepsin and the material immediately autoclaved at 10 lb. pressure for 10 min. Subsequent purification involved treatment with lead and silver salts and nitranilic acid, as described by Plentl and Page[6] for angiotonin. The material has been tested for pressor activity, following intravenous injection, by its effect on the resting blood pressure of a spinal cat, and Fig. 1 shows a typical response together with the response to 0·5 ml. 1/100,000 adrenaline; in this tracing a rise in blood pressure of 53 mm. in response to 7·5 mgm. of material is seen. The material stimulates the gastro-intestinal tract of the cat, causing vomiting and defæcation, and demonstrates tachyphyllaxis.

During the above experiments it was found that a substance is present in crude pepsin which will strongly inhibit the action of adrenaline but has not itself a depressor action. A suspension of B.P. pepsin in water at *p*H 6·0 was incubated at 37° for 2 hr., autoclaved at once at 10 lb. pressure for 10 min., filtered, concentrated *in vacuo*, and the final concentrate poured slowly into two volumes of acetone, left in the refrigerator over night, filtered and concentrated to a low volume. Fig. 2 shows the blood-pressure response of a spinal cat to 0·5 ml. 1/100,000 adrenaline, and the same dose administered 4 min. after intravenous injection of the inhibitory

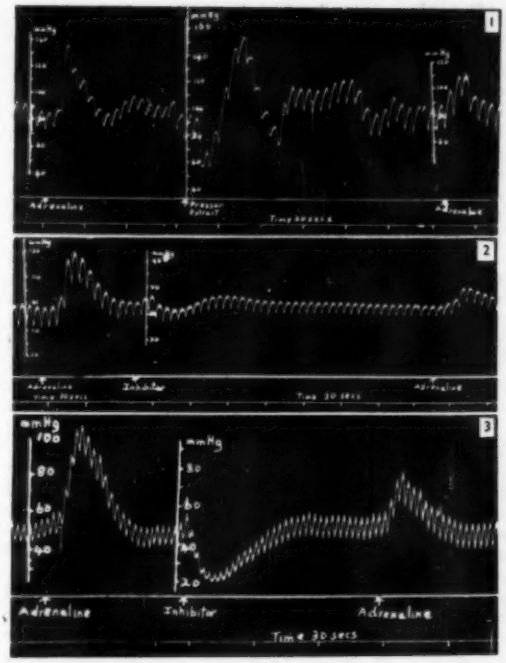

Fig. 1. Effect of pressor extract from hæmoglobin

Fig. 2. Inhibition of adrenaline by crude pepsin extract

Fig. 3. Inhibition of adrenaline by fresh aqueous hog mucosal extract

material; the action is prolonged, as the response to adrenaline was no greater 1½ hr. after injection of this material.

An aqueous extract of fresh minced hog mucosa from three stomachs was prepared; this was added to two volumes of acetone and the resulting supernatant concentrated *in vacuo*. The concentrate was extracted with ether, adjusted to *p*H 5·5, autoclaved at 10 lb. pressure for 10 min., filtered, added to two volumes acetone and the supernatant again concentrated, final volume 45 ml. On testing this material by the above method, it was found (see Fig. 3) that the response to adrenaline was diminished up to 4 min.; the material showed a slight depressor action. The presence of an inhibitor in fresh hog stomach suggests that that found in crude pepsin is not an artefact consequent upon the preparation of the pepsin.

Further investigation into the chemical nature and physiological action of these materials is in progress and will be described elsewhere.

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'Cytochrome c_1' of Yakushiji and Okuniki

Yakushiji and Okuniki[1] claimed to have demonstrated the existence of a new component (cytochrome c_1) of the succinic oxidase system, acting between cytochromes *b* and *c*, that is, with the same function as the respiratory catalyst which I have proposed. Since there is evidence that this catalyst[2,3] is a hæmatin compound, Keilin and Hartree[4] have recently suggested that it might be related to cytochrome c_1. The claim of the Japanese workers has now been re-investigated.

According to these authors, the band of cytochrome c_1 cannot be distinguished from that of cytochrome *c* in a normal heart muscle preparation, but when the latter is treated with bile salts, centrifuged and the supernatant precipitated with 0·5 saturated ammonium sulphate, a preparation is obtained which, on adding a reducing agent, shows a band at 552 mμ. If oxidized cytochrome *c* is added, the band at 552 mμ disappears and is replaced by that of reduced cytochrome *c* at 550 mμ.

Both Ogston and Green's[5] heart muscle preparation (used by Yakushiji and Okuniki) and Keilin and Hartree's[4] preparation were treated according to Yakushiji and Okuniki's directions for the preparation of cytochrome c_1. The resulting solutions had essentially the same properties, although the absorption bands were more pronounced in that obtained from Keilin and Hartree's preparation. Succinate did not reduce the cytochromes, even in the presence of potassium cyanide, showing the absence of an active succinic dehydrogenase. On the addition of sodium hydrosulphite, normal *a* and *b* bands were observed; but instead of an equally strong band at 550 mμ which is shown by normal heart muscle preparation, a weak band at 552 mμ was seen. Ascorbic acid (in the presence of potassium cyanide) reduced this latter band as well as the *a* band, but not the *b*, and was therefore a suitable reducing agent for observing the weak band. When a little oxidized cytochrome *c* was now added, the band at 552 mμ moved to 550 mμ.

Although these observations confirm those of Yakushiji and Okuniki in all essentials, further experiments did not support the explanation given by the Japanese workers. Treatment of a heart muscle preparation with bile salts has two effects: (1) it removes much of the cytochrome *c* into solution (the supernatant from the ammonium sulphate precipitation was found to contain much cytochrome *c*); and (2) it causes some denaturation of hæmatin compounds with the production of denatured protein hæmochromogen. As a result, the preparation obtained by Yakushiji and Okuniki's method is deficient in cytochrome *c* and contains denatured protein hæmochromogen. This is particularly the case when Ogston and Green's preparation is used as the starting material, since this preparation is itself deficient in cytochrome *c* and already contains denatured protein hæmochromogen. The presence of denatured protein hæmochromogen would cause the displacement of the band at 550 mμ towards the red (cf. the displacement of the *b* band towards the blue by such denatured compounds in Keilin and Hartree's kidney preparation[7]). Added oxidized cytochrome *c* would be reduced by excess reducing agent and the greater concentration of reduced cytochrome *c* relative to that of the denatured protein hæmochromogen would be expected to cause the band at 552 mμ to move back to 550 mμ, as was, in fact, found to be the case.

That this explanation of the change observed by the Japanese workers and confirmed in the present study is correct was supported by the finding that carbon monoxide caused the band to move from 552 mμ to 550 mμ. Carbon monoxide combines with denatured protein hæmochromogen, causing a weakening of the absorption band, without, however, having such an effect on cytochrome *c*, the spectrum of which is therefore seen undisturbed by that of these compounds.

Yakushiji and Okuniki's evidence for the existence of cytochrome c_1 is, therefore, unsatisfactory. In any event, even if the band at 552 mμ were due to a new component of the succinic oxidase system, this could not be the same as the component proposed by me, since a solution prepared by Yakushiji and Okuniki's method from a heart muscle preparation which had been treated with B.A.L. under such conditions as completely to destroy the latter component[2,3] had essentially the same properties as the solutions described above.

I wish to thank Prof. D. Keilin for his interest and advice.

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Application of Bacterial Kinetics to Biochemical Problems

It has been shown by Lodge and Hinshelwood[1] that when a basal glucose–ammonium medium is inoculated with bacteria from a similar medium, the lag period which develops depends upon the 'age' of the inoculating cells. If the latter were transferred early in their logarithmic phase of growth, a considerable lag period might develop which the authors termed 'early lag' and which they attributed to the diffusion from the cells of the metabolic intermediates necessary for rapid cell division to commence; sterile filtrates from fully grown cultures were able, for example, to effect a removal of this lag period because they supplied the cells with relatively high concentrations of the intermediates.

If this view of the 'early lag' period is accepted, it will be seen that kinetic studies of bacterial growth provide chemical microbiologists with a powerful tool, since a study of the response of 'early lag' to various compounds should reveal the nature of the intermediates and the reaction sequences which occur before cell division can commence. Working with *Bact. lactis aerogenes*, we have shown that cells harvested at the onset of the stationary phase, washed and stored in phosphate buffer, exhibit the phenomena of 'early lag' when used as inocula for a glucose–ammonium basal medium. Both 'early lag' and lag produced by washing are partially removed by various amino-acids, notably by glutamate at concentrations of 5–10 parts per million; and while various anions containing no nitrogen, such as malate, fumarate, citrate and acetate showed small responses,

the effect of succinate was pronounced and was, in fact, comparable with glutamate. We may conclude that succinate, which is formed under the conditions of our experiments as an end product of glucose breakdown in the old culture, is a building brick for syntheses in the new; and that, of the amino-acids eventually synthesized from it, glutamate is the most important. The development of these views has prompted us to investigate the following problems.

The necessity of carbon dioxide for bacterial growth. When basal media are thoroughly freed from carbon dioxide by a stream of purified air, the growth of *Bact. lactis aerogenes*[2] and other bacteria is delayed indefinitely[3]. Work by Elsden[4] has indicated that carbon dioxide can be assimilated to form succinic acid, and Werkman and his colleagues[5] using isotopic carbon confirm the suggestion. In view of the role of succinic acid in the lag phase of *Bact. lactis aerogenes* to which we have directed attention, it is significant that growth of this strain begins almost immediately if about ten parts per million of succinic acid is added to the basal glucose medium containing a little pyruvate, even though thoroughly aerated with a carbon dioxide-free stream. Growth has been reported in rich media aerated by a carbon dioxide-free stream on previous occasions and has been attributed to the production of sufficient carbon dioxide for growth, by fermentation. An alternative explanation, suggested by our experiments, is that the rich medium supplies nutrients the synthesis of which, had they been absent, would involve the participation of carbon dioxide.

Metabolism of sulphate ions. Experiments with mutant strains of *Esch. coli*[6] indicate that bacteria metabolize sulphate according to the following sequence[7]:

$$\rightarrow SO''_4 \rightarrow SO''_3 \rightarrow S'' \rightarrow \text{cysteine} \rightarrow \text{cystathionine} \rightarrow \text{homocysteine} \rightarrow \text{methionine}.$$

We have shown that several of the compounds in this sequence reduce 'early lag' in basal media where the sole source of sulphur is sulphate. It is of interest to note that sodium sulphide can remove a small but definite fraction of lag at a concentration of a few parts per million.

Action of phenol and other drugs. When cells of the present strain are taken at the point of minimum lag and inoculated into a basal medium also containing 0·4 gm./litre of phenol, a lag period of several hours develops; but the growth-rate and stationary phase remain largely unaffected. Small amounts of glutamate, succinate and methionine cause large reductions in this type of lag, and we may assume that phenol owes its bacteriostatic action to its ability to inhibit these initial syntheses. Similar results have been obtained when the lag was produced by alcohols, ketones, esters and other narcotics. Other amino-acids and organic anions which reduce 'early lag' in different degrees do not, however, reduce lag produced by phenol; in fact, they increase it; and it may be supposed that the phenol also inhibits the processes by which these other amino-acids are converted into glutamate.

Work is still in progress on these problems, and a full account will be published elsewhere.

Addition in proof. During the progress of these investigations, S. J. Ajl and C. H. Werkman (*Arch. Biochem.*, **19**, 493; 1948) published a full account of work with *Esch. coli* in which they demonstrated that several compounds taking part in the Krebs's oxidation cycle, including succinic acid, removed the necessity for carbon dioxide in a basal medium.

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Effect of Histamine on Hyaluronidase Activity

According to modern investigations, the rheumatic and allergic inflammations are characterized by the pathologically increased activity of hyaluronidase. This enzyme hydrolyses the amorphous mucoids of the connective tissue and increases its permeability[1]. But it has not yet been possible to establish why the activity of hyaluronidase increases.

Bearing in mind the histamine theory of the rheumatic and allergic inflammations, we have investigated whether histamine might be responsible for the increase of hyaluronidase action. The activity of hyaluronidase—measured *in vitro* by viscosimetric assay—was not influenced at all by histamine or by synthetic antihistamines. These results are inconsistent with the experiments of Swyer[2], and Mayer and Kull[3], who found that *in vivo* histamine increases, and antihistamines oppose, the spreading effect of hyaluronidase.

Further, we investigated the cause of the difference between the *in vivo* and *in vitro* effects of hyaluronidase. It is known that heparin inhibits hyaluronidase[4], and that histamine opposes certain effects of heparin. Therefore we investigated whether histamine hinders the hyaluronidase-inhibiting effect of heparin. Hyaluronidase action was measured again by the viscosimetric method. When hyaluronidase was inhibited by heparin, histamine opposed this inhibition, and the effect re-appeared with its original speed.

From these results we envisage the mechanism of the increase of hyaluronidase action as follows: histamine, released during rheumatic inflammation, opposes the hyaluronidase-inhibiting action of heparin, and therefore increases the activity of hyaluronidase.

Further work is in progress to establish what kinds of pharmacons are able to prevent the histamine–heparin antagonism, and hence to deal with this important symptom of rheumatic inflammation, namely, the increase of hyaluronidase activity and of permeability.

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Enzymic Inactivation of Serum Gonadotrophin

GONADOTROPHINS resemble blood-group specific substances in several respects. Meyer[1] has classified these compounds together as neutral mucoids; Bussard and Eyquem[2] claim to have demonstrated a serological relationship between blood-group substances and chorionic gonadotrophin. McShan and Meyer[3] have observed inactivation of gonadotrophins by human saliva, whereas Schiff and Akune[4] found that this material destroyed blood-group *A* substance. In addition, it has been shown that blood-group substances[5,6] and serum gonadotrophin[7] are substrates of the receptor-destroying enzyme produced by *Vibrio cholerœ* and of the similar enzymic component of influenza virus. It would appear, then, that gonadotrophins and blood-group substances have a similar structure and may be inactivated by the same enzymes. This hypothesis was further examined by studying the action on serum gonadotrophin of enzymes which decompose blood-group specific substances.

Morgan[8] has shown that *Clostridium welchii* culture filtrates contain enzymes which destroy the serological characteristics of *A*, *B* and *O* substances. The property of destroying *A* and *B* substances is lost after heating for 1 hr. at 56° C., but the activity against *O* substance is retained. A sample of *Cl. welchii* (Type *B*) culture filtrate, partially purified with respect to these enzymes, was kindly supplied by Dr. W. T. J. Morgan, of the Lister Institute. The action of this preparation on serum gonadotrophin has been examined.

Aliquots of the hormone dissolved in phosphate buffer *p*H 7·0 were incubated at 37° C. for 1 hr. with an equal volume of (1) saline (control), (2) 1 in 1,000 solution of enzyme, (3) 1 in 1,000 solution of enzyme which had been held at 56° C. for 1 hr. The activity of the treated hormone was assessed by injecting the equivalent of 50 I.U. of the original hormone into each of groups of ten female rats weighing 40–50 gm. The animals were then treated in the usual manner for assay of serum gonadotrophin. Mean ovarian weights obtained during a typical experiment are given in the accompanying table. It is clear that the hormone was inactivated by the heated and unheated enzyme preparations. Since it was found that the preparation possessed no receptor-destroying activity, and testicular hyaluronidase failed to inactivate the hormone, it appears unlikely that the inactivation observed was due to either of the other two recognized mucolytic enzymes produced by *Cl. welchii*.

Treatment	Mean ovarian wt. (mgm. ± S. E.)
Serum gonadotrophin, 50 I.U.	151 ± 4
Serum gonadotrophin 50 I.U. incubated at 37° C. for 1 hour with	
1. Saline (control)	144 ± 6
2. Enzyme preparation	16 ± 1
3. Enzyme preparation held at 56° C. for 1 hour	18 ± 1
Uninjected animals	16 ± 1

The results indicate that the preparation contained one or more substances which inactivate serum gonadotrophin. That one of these may be identified with the enzyme destroying blood-group *O* substance seems probable. However, the action of the enzymes which destroy the other blood-group substances cannot be discounted.

The present work, though requiring confirmation with purified enzymes, suggests that gonadotrophins and blood-group substances are similar in that they form common substrates for certain enzymes.

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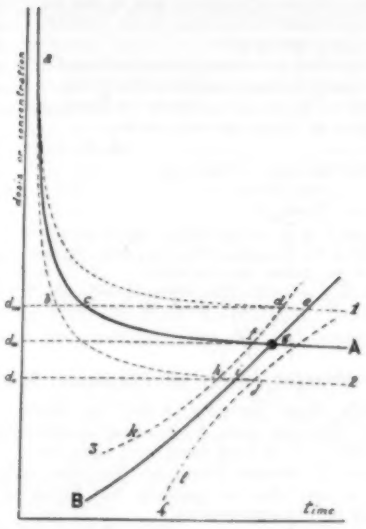
A Method for Reducing the Number of Pharmacological Assays

THE time-concentration curve for the production of a selected drug effect has a well-known shape, the best expression for which approximates to the formula $(C - C_m)\ (t - t_m) = \text{constant}$. In fact, there is a minimum concentration C_m below which the drug will not produce the biological action, and it is certain that in many cases there must be a time t_m corresponding to the production of a delayed effect, after the time t needed for the fixation of the drug upon receptors. In some cases $C.t = \text{constant}$ gives an approximate fit; but this merely implies that C_m and t_m are so small as not to produce a measurable error.

On the other hand, if the effect selected is reversible and detoxication occurs, the time after which complete recovery takes place may be plotted against dosage, and a curve that approximates to a straight line is obtained when the detoxication-rate is supposed to be constant over a sufficiently large range of values. Should the detoxication-rate, according to the mass action law, be proportional to the amount of drug fixed, a logarithmically rising curve would be the rule. The theoretical meaning of C_m and t_m, as well as a complete theory of both the time-concentration curve and the duration-dosage curve, will be given in a subsequent paper.

From the practical point of view, however, it is of interest to note that if both these curves are plotted in the same system of co-ordinates, they intersect in a point which represents the minimum active dose for the effect selected, or at least the dose which is worth considering experimentally, since the threshold C_m has only a boundary significance. Furthermore, this point of intersection is to a large extent independent of the statistical distribution of sensitiveness in response to drugs. In fact, in the case of a symmetrical distribution of variation, hyperbolæ 1 and 2 may be assumed to be the limits of the reaction curve *A*; and hyperbolæ 3 and 4 the limits of confidence of the duration curve *B*. Points representing dosages greater than d_{100} lie in the space *abcd*, and since the probabilities of deviation from the median only differ from each other by the plus or minus sign, the sensitiveness of the effectors is not concerned: the points can be used, therefore, for calculating the reaction curve *A* by the usual method of least squares. Similarly, points representative of dosages less than d_0, which must lie in the space *khjl*, can be used for calculating the



duration line *B*. Only for dosages between d_0 and d_{100} does the individual variation play a part, effectors of resistance less than 50 per cent corresponding to the space *bcfh*, whereas points representing higher resistant effectors lie in *deih*. No representative points are comprised in the space *cfd* or at the right side of *egij*, unless they exceed the limits of confidence, in which case, however, they may be neglected.

It is clear that the point *g* represents the minimum effective dose for effectors of mean sensitivity, for example, the 50 per cent variation in any function connected with a particular stage in a graded action, or the L.D. 50 if curves of mortality in a population of small organisms are concerned. In the case of a skewed distribution of variation, the relative distance of hyperbolæ 1, 2 — 3, 4 from the median curves *A* and *B* changes; but the general shape of the graph remains similar and its heuristic value unchanged.

The foregoing enables us to determine the point *g* with an extremely small number of assays, since the development of the whole Trevan curve, giving the exact percentage of action for each dose between d_0 and d_{100}, becomes superfluous. Using the points lying in the neighbourhood of $a - c$ for calculating the hyperbola (after substituting the reciprocal value of the survival times to convert the hyperbola in a straight line, and then employing the reciprocal value of the constants obtained to recalculate the reaction curve *A*), and those of the region *gkl* for the duration line *B*, the degree of accuracy generally obtained with a score or so of animals is very unlikely to be further improved by increasing the number of assays to a hundred or more.

I have tested this method with digilanides on the frog heart to study detoxication-rates, with antihistaminic compounds on guinea pigs for quantitative measurements of antagonism, with mixtures of methyl donors and acceptors in order to control transmethylation-rates in mice, and in several other cases, with very satisfactory results.

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Possible Influence of Inbreeding on Evolution

According to Zeuner[1] one of the difficulties of explaining evolution by the mutation theory is to account for the fact that elephants, which have the slowest rate of breeding, have had the fastest rate of evolution.

Those species producing the greatest number of generations in a given time might reasonably be expected to give rise to the greatest number of mutations and therefore to evolve the most rapidly. A possible solution of this anomaly has occurred to me.

Nearly all the mutations which might be of significance for evolution are recessive. Recent research[2] has suggested that certain recessive genes can exert some influence on the survival prospects of individuals carrying them in the heterozygous condition. But it would seem that any factor which increases the chances for advantageous recessive mutations to appear in the homozygous state and thereby expose their full expression to the influence of natural selection should accelerate the rate of evolution.

The most effective factor of this kind is inbreeding, and elephants practise it to a considerable extent. Wild herds are served by a few dominant bulls which appear to mate regularly with their own daughters and are often succeeded by their sons. At the same time, owing to the migrations of young males, there is some interchange of genes between neighbouring herds. The elephant stocks, being split up into groups of semi-isolated colonies, therefore seem to provide the condition which, according to Sewall Wright[3], is most favourable for evolution.

If the increased rate of evolution of the elephants has been due to the rapid exposure of recessive mutations by inbreeding in this way we might expect to find a large number of divergent species among ancestral forms.

The fossil record supports this contention. More than three hundred extinct species of elephants are known: only two species are living.

The same argument would seem to apply to deer, which practise a similar kind of group inbreeding and have had an exceptionally rapid rate of evolution. It may also have applied to wild horses and possibly to rhinoceroses. Keith[4] has argued with considerable cogency the case for the importance of inbreeding in the development of the anthropoid apes and early men.

If some measure of evolutionary advantage be conceded to inbreeding, it is possible to ascribe 'biological sense' to certain phenomena which would otherwise seem to have little meaning.

There seems, for example, to be little other advantage in the remarkably developed homing behaviour of the salmon. It has been established that spawning Atlantic salmon return not only to the river of their birth but often to the very creek in which they were hatched. This must certainly result in a degree of inbreeding which would not occur otherwise.

The same argument may be applicable to the migration of storks, swallows and other birds which regularly return to the same neighbourhood to nest.

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Ciliary Mechanisms in *Aurelia aurita*

During the last two years attempts have been made to review the work of Widmark[1], Gemmill[2], and Orton[3] on the ciliation and mode of feeding in *Aurelia aurita* (Linné). The investigations have not been completed owing to the difficulty in obtaining healthy living material, which is essential for a study of this kind; but certain important features have been established and are worth recording in view of the apparently contradictory accounts in the literature.

Widmark's description[1] of the internal ciliation and Orton's[3] of the external ciliation in the adult *Aurelia* have both been confirmed essentially and make a connected story. The most interesting fact is the occurrence of two well-defined ciliated tracts, beating simultaneously in opposite directions, on the inner ventrally directed surfaces of the oral arms; these tracts are (*a*) the basal, forming a median ciliated groove in the angle between the two inner faces of each arm, and (*b*) the sub-marginal, composed of the two ciliated lateral inner faces in apposition. In the adult, the two inner faces are normally closely apposed, separation being partly prevented by the cartilaginous nature of the mesoglœa.

The cilia of the basal tract beat away from the mouth, towards the distal tip of the arm; those of the sub-marginal tract beat towards the mouth. A good preparation can be made to show these tracts by cutting off an oral arm and adding carmine suspension to the cut end of the basal tract while feeding coarse plankton to the distal tip. Both tracts can be seen in this way to be operating simultaneously.

Thus, in the adult *Aurelia*, plankton is collected in the sub-marginal tracts of the oral arms from various sources[3], passed along the arms to the mouth, proceeding by way of the gastrogenital canals to the gastric pouches, where the food undergoes some digestion. From the gastric pouches the food is distributed to the internal canals by the currents described by Widmark[1]. Excretory products and indigestible matter are collected by (*a*) the per-radial canals, and (*b*) the inter-radial and lateral gastro-oral arm canals, which deliver them to the origins of the oral arm basal tracts. In the basal tracts the excreted material passes to the exterior.

The full purpose of the lateral gastro-oral arm canals will not be made clear until healthy, growing and sexually mature *Aurelia* can be examined in the laboratory.

Confirmation has been obtained of the following observations: (*a*) the ciliation of the ex-umbral surface of the adult *Aurelia* and the transference of carmine particles by cilia from the ex-umbral surface and between the lappets into the circular food groove and thence to the food pouches[3]; (*b*) the ciliation of the sub-umbral surface and the transference of carmine particles by cilia from the sub-umbral surface to the circular food groove and food pouches; (*c*) combined ciliary and macrophagic feeding in the ephyra and young stages, as shown by Gemmill[2] and Lebour[4]. It has also been found that the outer dorsally directed surfaces of the oral arms have cilia beating towards the marginal tentacles, that mucus production is of great importance in food collection and food transport, and that there are indications of *p*H control of mucus viscosity[5].

In the growth of *Aurelia* from the ephyra to the adult, the originally wide communication between the mouth and gastric pouches becomes restricted finally to four narrow canals. In correlation with this are the observations of macrophagy in the early stages[2,4], with a probable restriction to an entirely planktonic diet in the later stages[3].

The studies are being continued and will be completed and published in detail elsewhere. I am greatly indebted to Prof. J. H. Orton for much guidance and assistance in these investigations.

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Weight, etc., of Elephant Seal

There were recently killed in South Georgia twenty elephant seals, for special examination as to production of oil and meat and bone meal. By the courtesy of Messrs. Christian Salvesen and Co., of Leith, I am able to publish the following figures relating to the experiment.

Of special interest was the weighing of an entire animal in pieces. The total weight was 4,357 lb., and the blood, much of which would be lost, was estimated at 218 lb., almost exactly 5 per cent.

Length: 13 ft. 4 in., presumably nose to tail.

	Lb.	Percentage of total
Skin	265	6·10
Blubber	1469	33·70
Meat	923	21·19
Bone	688	15·79
Flippers, fore	174	3·98
,, hind	70	1·61
Head	114	2·62
Heart	20	0·46
Liver	110	2·53
Spleen	25	0·58
Lungs	90	2·06
Kidneys	14	0·32
Stomach	72	1·65
Intestines	90	2·06
Tongue	15	0·35
Blood (calculated)	218	5·00
	4357	100·00

The fore flippers include shoulder-blade. Stomach and intestines were quite empty.

Composition of tissues

	Blubber	Meat	Bone	Stomach	Intestine
Moisture (per cent)	13·0	71·2	43·2	79·8	80·1
Oil (per cent)	84·0	2·1	19·5	0·2	0·4
Solids (per cent)	3·0	26·7	37·3	20·0	19·5

	Lungs	Heart	Kidneys	Tongue	Liver
Moisture (per cent)	80·3	73·8	77·8	61·5	72·0
Oil (per cent)	0·7	0·5	0·3	21·8	1·4
Solids (per cent)	19·0	25·7	21·9	17·7	26·6

The twenty animals produced averages of 1·8 barrels of oil from the blubber and 0·45 barrels from the carcases, 2·25 barrels or 90 gallons (1 barrel = 40 gallons) per seal.

Meat and bone meal from the residues amounted to 1,625 kgm. Analysis of this product gave the following result:

Moisture	4·7 per cent
Oil	18·6 ,,
Protein	58·8 ,,
Tricalcium phosphate	17·1 ,,
	99·2 ,,

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Detection of Elementary Sulphur

A REACTION is known to take place when organic compounds containing hydrogen are heated above the melting point with elementary sulphur. Among other decomposition products hydrogen sulphide is evolved, and its evolution is especially marked when a polyhydric phenol, for example, hydroquinone or pyrogallol, is the reducing agent. The generation of hydrogen sulphide for laboratory use from a melted mixture of sulphur and paraffin wax is perhaps a more familiar example of the reaction. So far as can be ascertained from the literature, the analytical possibilities of the reaction have not been explored previously, yet it affords a means of detecting sulphur quickly and conveniently in complex or coloured materials, provided they are not too readily combustible.

A small quantity of the substance to be tested is mixed in the dry, powdered state with an equal weight of a polyhydric phenol, for example, hydroquinone or pyrogallol, and the mixture heated in a bulb tube to melting point. A freshly moistened lead acetate paper held in the issuing vapours is promptly stained brown when sulphur is present. Under such simple conditions it has been found that 0·0001 gm. of sulphur can be detected, but it is possible that an even higher degree of sensitivity might be attained.

The behaviour of the test with a few typical sulphur compounds was observed; metallic sulphates, sulphides and sulphonates appeared to be unreactive, whereas sulphites were slowly reduced and yielded hydrogen sulphide after a period of heating. Thiourea yielded hydrogen sulphide. Presumably any organic sulphur compound which decomposes on heating would respond.

The test promises to be of value in the examination of pigmented materials, dyestuffs and carbonaceous matter, and although it has obvious limitations may prove useful in qualitative analysis as a confirmatory test for free sulphur or as an aid in the identification of organic sulphur compounds.

From preliminary experiments, it would appear that the conversion of sulphur to hydrogen sulphide with polyhydric phenols is quantitative, and that the reaction can be made the basis of a method for estimating sulphur. Work has been carried out in this direction which it is hoped to report later.

Thanks are accorded the Chief Scientist, Ministry of Supply, for permission to publish this note.

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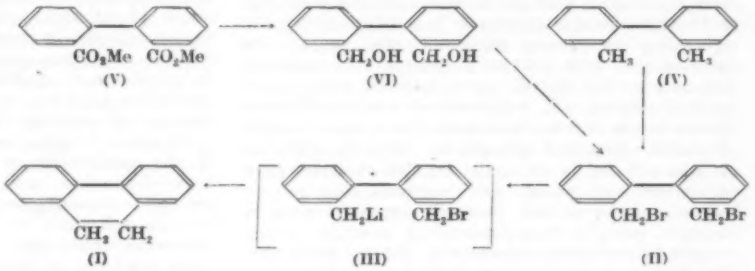
A New Route to Dihydrophenanthrene

WE are at present engaged in the investigation of the configurations of certain reduced aromatic systems, and have been surprised to find how relatively inaccessible is 9 : 10-dihydrophenanthrene (I). Quite apart from the appreciable difficulty of obtaining pure phenanthrene, the reduction of this hydrocarbon requires experimental procedure which is unattainable in many university laboratories. Burger and Mosettig[1] effected the dihydrogenation by using a copper–chromium–barium oxide catalyst at 220°, with a hydrogen pressure of about 200 atmospheres over a period of about nine hours.

Wittig and his co-workers[2] had observed the conversion of benzyl bromide into *s*-diphenylethane by the action of lithium phenyl, which produced lithium benzyl, the latter at once reacting with unchanged benzyl bromide to give diphenylethane. It therefore seemed probable that 2 : 2′-di-(bromomethyl)diphenyl (II) would react with lithium phenyl to give the mono-lithium compound (III), and that intramolecular reaction between $.CH_2Br$ and $.CH_2Li$ would be quicker than interaction between the same groups in two different molecules. This proved to be true, the reaction being complete in a matter of seconds and the yield of dihydrophenanthrene being 80 per cent.

Kenner and Turner[3] obtained impure dihydrophenanthrene in poor yield by the action of sodium



on 2 : 2′-di-(bromomethyl)diphenyl, which they made by brominating 2 : 2′-ditolyl (IV), formed by an Ullmann reaction on *o*-iodotoluene. We find that the ditolyl can be obtained in 40 per cent yield by the Krizewsky–Turner[4] reaction (cupric chloride on *o*-tolyl magnesium bromide) and that Kenner's bromination conditions cannot be greatly improved.

We have also now found that dimethyl diphenate (V) is quantitatively reduced by ethereal lithium aluminium hydride[5] in a few minutes to the hitherto unknown 2 : 2′-di-(hydroxymethyl)-diphenyl (VI), m.p. 112–113 (found: C, 77·9; H, 6·8; $C_{14}H_{14}O_2$ requires C, 78·5; H, 6·8 per cent), and that this alcohol reacts smoothly and rapidly with aqueous hydrobromic acid at about 100° to give 2 : 2′-di-(bromomethyl)diphenyl. Combining the three stages, it is thus possible in little more than a day's work to convert dimethyl diphenate, a readily available substance, into dihydrophenanthrene in an overall yield of about 70 per cent. We are investigating the general applicability of the method.

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THE FEULGEN NUCLEAL REACTION

Acid Degradation of Sperm Deoxyribonucleic Acid

WE have been seeking methods for preparing deoxyribonucleotides and nucleosides by chemical degradation of sperm deoxyribonucleic acid under acid conditions, and thought it of interest to test for liberated aldehydo groups on the various products. The results have proved of some interest in regard to the views of various workers on the interpretation of results of the Feulgen reaction[1] and more particularly in the light of views described by one of us with another colleague in the following communication.

Sperm deoxyribonucleic acid, prepared in typically fibrous form from soft herring roe by the elegant method of Mirsky and Pollister[2], can be freed from all but traces of protein by chloroform/butanol treatment and appears to be combined with protein in sperm by electrovalent linkages. Such material slowly becomes Feulgen-positive on being steeped for two to three hours in Schiff's reagent at *p*H 3. This deoxyribonucleic acid can be irreversibly depolymerized by dialysis of a solution of its sodium salt against tap water for several days, or more rapidly by autolysis (*p*H 3) at 100° for 3 minutes. The product, prepared by the dialysis method, when precipitated by acid ethanol (*p*H 3·5), loses all semblance of its fibrous nature and can be obtained as a white powder of almost crystalline appearance. It is insoluble at an acid *p*H and is converted into an insoluble gum on contact with water. On treatment with Schiff's reagent, the gum-like product instantly gives a strongly positive Feulgen-staining reaction which reaches its maximum intensity in about three hours. The dye so formed is completely non-soluble and non-diffusible, the reagent above the dyed nucleic acid remaining clear for more than thirty hours (cf. Stedman[3]).

The most significant finding is that this partly degraded product having a slightly higher nitrogen content than the original (N/P = 11/3) still retained almost completely its content of purine bases, so we have shown, in contrast to Feulgen's original ideas, that it is unnecessary to remove all purine bases to obtain Feulgen-positive material. We believe that polymeric linkages, by which the maximum macromolecular state (such as is possessed by material isolated in the fibrous form) of native deoxyribonucleic acid is maintained, involve highly labile sugar aldehydo linkages, and these can readily be broken by acid or depolymerase enzymes. For more profound chemical degradation under acid conditions we have used sperm deoxyribonucleic acid provided by the Glaxo Laboratories, Ltd., and have treated it initially with 1·5 per cent methanolic hydrogen chloride at room temperature. We anticipated that such a method would protect any sugar aldehydo groups by acetal or glycoside formation, would not convert deoxyribose into ω-hydroxy lævulinic aldehyde and would not remove organically bound phosphate residues.

We have obtained clear evidence that the first components to be liberated are, indeed, the purine-containing fractions, which pass into the methanolic hydrogen chloride solution, in which they can be estimated by ultra-violet absorption methods, and then isolated in crystalline form or as the picrates. The methanol-insoluble residue remaining after the bulk of the purine bases have been removed corresponds in properties to a methyl derivative (N, 7–8; OMe 6–7 per cent) of the well-known thymic acid[4]. It is soluble in water, $[\alpha]_D + 30°$, and after mild acid treatment (*p*H 3) to remove methoxyl groups, or standing in Feulgen's reagent, it gives an intense 'Feulgen-positive' stain with Schiff's reagent. The dye formed is completely soluble in water, and if diffused into protein material is strongly adsorbed by the protein as in Stedman's experiments[3]. From the modified thymic acid, by increasing step-wise the acid concentration in the methanolic hydrogen chloride treatment up to *p*H 3·6, we have obtained a variety of soluble and insoluble fractions which are difficult to characterize precisely.

Using elementary analysis for carbon, hydrogen, nitrogen and phosphorus, Feulgen and Dische[5] estimations, ultra-violet absorption and the usual methods for estimating purine bases, we have obtained evidence of the presence of guanine, adenine, 'sperm guanosine', 'sperm adenylic' acid and deoxyribose phosphates. There invariably remained a residue completely insoluble in methanolic hydrogen chloride consisting apparently almost completely of the more stable 'sperm thymylic' acid, from which crystalline thymine in good yield can readily be obtained by sublimation methods.

We think it highly improbable from the proportion of the nucleotides so far estimated that sperm deoxyribonucleic acid contains a simple tetranucleotide repeating unit, and consider that Levene's[6] formula will need to be revised to apply to this deoxyribonucleic acid. From the ease of liberation of sugar aldehydo groups, there would appear to be no reason to doubt that the Feulgen reaction in the hands of cytologists does locate deoxyribonucleic acid at the precise site of its occurrence. On the other hand, the varying intensities of the Feulgen colour, as noted particularly by Bauer[7] and Hillary[8] (see also Stefano[9]), can readily be accounted for by the high lability under acid conditions of deoxyribonucleic acid and more particularly of its deoxyribofuranose component (see following communication).

We thank the local committee of the British Empire Cancer Campaign for a grant in aid of this work.

CHONG-FU LI
M. STACEY

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Mechanism of the Feulgen Nucleal Reaction

In a previous paper[1] from these laboratories, it was shown that the mechanism for the Dische[2] diphenylamine reaction for deoxyribonucleic acid depends upon the conversion by acid treatment of the deoxyribose component into ω-hydroxy lævulinic aldehyde, which then coupled with diphenylamine to give a blue dye with a characteristic absorption band. Extension of this work with Dr. Ethel Teece has led

to the isolation in 10 per cent yield of an amorphous blue complex possessing the characteristic band.

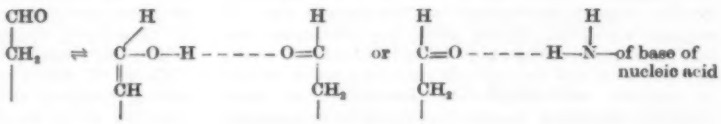
The view was expressed[1] that, under the acid conditions of the Feulgen[2] reaction, the possible formation of this aldehyde presumably accounted also for the reaction with the Feulgen reagent, though it was noted that the colours of Schiff reagent – aldehyde reactions were variable. It was pointed out by Danielli[4] that an aldehyde with such a small molecular weight would readily be washed out of tissues under the correct method of carrying out Feulgen's test, and that some other mechanism must account for the stain. On the other hand, under the conditions of test, where unduly strong acid conditions obtain, such an aldehyde could form a diffusible complex with Schiff's reagent and could account for the observations which in our opinion have misled Stedman in some of his views on chromosome structure. It was obvious, particularly in view of the controversies regarding the Stedmans' claims[5] to ascertain the true mechanism of the Feulgen reaction. It was clear that, for this purpose further knowledge on deoxy sugars, especially in regard to their acid lability and to the relationship between their aldehydo forms and ring structures, was necessary.

Accordingly, we have devised new syntheses for 2-deoxyribose and have synthesized a number of other 2-deoxy sugars with both pyranose and furanose derivatives thereof. In addition, we have synthesized a variety of 2-deoxy glycosides. We have carried out the quantitative Schiff's test using the sensitive reagent described by Tobie[6], under a variety of rigidly controlled conditions on both pyranose and furanose derivatives of the ordinary sugars and of their 2-deoxy analogues. It was possible to demonstrate that under identical conditions 2-deoxy sugar derivatives contain a significantly higher proportion of the aldehydo form than do the normal sugars, whereas derivatives of the 2-deoxy furanose sugars contain an appreciably higher proportion of the aldehydo form than is contained by the corresponding derivatives of 2-deoxy pyranose sugars. These differences were quite striking in the galactose and glucose series, but less so in the ribose series, in which we have so far not yet obtained crystalline 2-deoxy ribofuranose derivatives. With the latter it will probably need the 2-deoxy ribofuranose phosphates, now in course of preparation, to get the maximum intensity of Schiff's colour. In examining the glycosides of some 2-deoxy sugars, we find that under acid conditions the glycosidic groups of the furanose types are quite remarkably labile.

Now turning to the reaction between aldehydes and Schiff's reagent, we have the view of Wieland and Scheuing[7], which seems reasonable, that the aldehyde forms an actual complex with *para*rosaniline decolorized by sulphur dioxide. Later workers express similar ideas. In view of this work, and also accepting the assumption, for which there is some evidence, albeit slight, in the literature that the deoxy sugar component presumably occurs naturally in deoxyribonucleic acid in the furanose form, we consider that the mechanism of the Feulgen reaction can now be explained as follows.

Under acid conditions, those sugar linkages engaged in polymeric bonding first become broken, and this reaction is followed by the rupture of the linkages attached glycosidically to purine bases. The 2-deoxyribose components thus revealed are still attached through phosphate linkages at C_3 and C_5 in the main chain of the nucleic acid and consequently are firmly held in the furanose form, which immediately is transformed into a significant proportion of the aldehydo form. The Schiff's reagent then reacts with the revealed aldehydo groups and becomes attached in the manner postulated by Wieland and Scheuing, giving an insoluble coloured macro-molecule of the type: [Nucleic acid—aldehydo groups]—*para*rosaniline-SO_2 dye.

From the work with Dr. Li outlined above, it would appear to need only a few of the sugar aldehyde residues to be liberated in order to give definite Feulgen-stained material, and it is clear that, in such a complicated molecule, under optimum conditions a maximum amount of the dye can be formed. It is even more apparent how readily varying intensities up to the maximum can arise owing to the lability of sugar aldehyde attachments and to the instability of the 2-deoxyfuranose sugar component itself. Similarly, losses in intensity by over-hydrolysis can now be explained. We believe that in sperm deoxyribonucleic acid, C_1 of the deoxy sugar is engaged in two distinct types of linkages, (*a*) a form of polymeric linkage, and (*b*) a glycofuranosidic attachment to the purine (and possibly to the pyrimidine) bases, and that both types are acid-labile. The polymeric type could be no more than some enolic form giving hydrogen bonding which, for example, could be achieved as follows:



Alternatively, it could involve highly labile 'glyconidic' phosphate residues.

Two important conclusions appeared to come from our work: (1) the explanation of the purine-sugar attachments as being of the 2-deoxy glycofuranosidic type; and (2) if properly carried out, the Feulgen reaction can locate a deoxyribonucleic acid at the site where it occurs. To prove (2), protein-free sperm deoxyribonucleic acid was treated in a citrate buffer at *p*H 3 at 100° C. for 2·75 minutes (Widström[8] modification of the Feulgen reaction) and then cooled by plunging into ice-water. The liberated purines were estimated in the solution by ultra-violet absorption spectra measurements. The polymeric material present was collected by adding ethanol and physiological saline[9], and was washed exhaustively with dilute saline and water. On addition of Schiff's reagent the solid *instantaneously* developed an intense Feulgen-positive stain, the solution above it remaining completely colourless even after twenty-four hours standing. This illustrated that no diffusion could have occurred such as is postulated by the Stedmans[10]. Moreover, control experiments showed that certain simple aldehydes could be washed out of proteins, nucleic acids and nucleoproteins which had been steeped in these aldehydes; consequently an aldehyde of small molecular weight could not be responsible for any diffusible stain which could be absorbed on to the protein (cf. ref. 10).

We would emphasize that we believe that, in the hands of the cytologist, the Feulgen reaction

does locate the precise site of deoxyribonucleic acid.

We thank the Board of the British Rubber Producers' Research Association for a grant.

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Sept. 22.

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PROPERTIES OF THE α-PARTICLE SPARK COUNTER

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IT is the object of this communication to give a preliminary account of certain investigations of the Rosenblum-type spark counter for α-particles. In the course of this work it has been shown that the original wire-plate arrangement[1] is a particular case of a more general type of counter in which the anode is a fine wire and the cathode may be convex, planar or concave with respect to the anode, all these counters operating in air at atmospheric pressure, with electrode separations of the order of 1 mm.

The anode should be a wire of about 0·05 mm. diameter and, since it is important that this wire be kept taut, it should be of a material capable of withstanding considerable tension. Tungsten was chosen as the most suitable anode material on this account. Several cathode materials have been tested, and copper and brass have been found to be as good as any others, the cathode surface being polished to remove irregularities. If a wire cathode is used to give a convex cathode surface, the diameter of the cathode should be several times that of the anode wire, the axes of the two electrodes being parallel. Using a hollow cylinder to give a concave cathode, a slit or window should be provided in the cylinder to permit entry of the α-particles into the sensitive volume.

With the cathode connected to a negative high-tension supply, stabilized but variable up to 4 kV., and a resistance-capacity potentiometer connected from anode to earth, such arrangements have been found to be simple and convenient α-counters, giving visible and audible sparks when a source is brought within α-range of the counter. The potentiometer serves to quench the spark discharge; also, by tapping off a small fraction of the impedance of the potentiometer, a pulse of suitable size can be obtained for the operation of a scaler or cathode ray oscillograph. In this connexion it has been shown that the pulse developed across the total quench impedance is approximately equal to the voltage appearing across the electrode gap prior to discharge. The leading edge of the pulse is sharp, the time of rise being estimated as less than 10^{-7} sec. The recovery-time is largely determined by the time-constant of the quench circuit, and values of the order of 50 μsec. have been found convenient. It has not been found possible to achieve stable operation when the time-constant is less than about 20 μsec.

For the counter to spark, the electron avalanche reaching the anode must exceed a critical size. The probability of sparking will therefore be a function of the gas pressure, the geometrical arrangement and applied voltage which produces the field in the electrode gap, and the specific ionization of the α-particle in the sensitive region of the counter. It is found experimentally, over a wide variety of conditions, that the counting efficiency varies with the residual range of the α-particle, being a maximum when the residual range is small. β-Rays are not counted, the avalanches they create being insufficient to produce a spark; also, in the absence of an α-emitting contamination, the background is zero.

In all its forms the spark counter is 'directional', having greatest sensitivity for α-particles arriving normally to the anode wire and very small sensitivity for particles entering parallel to the electrodes. With

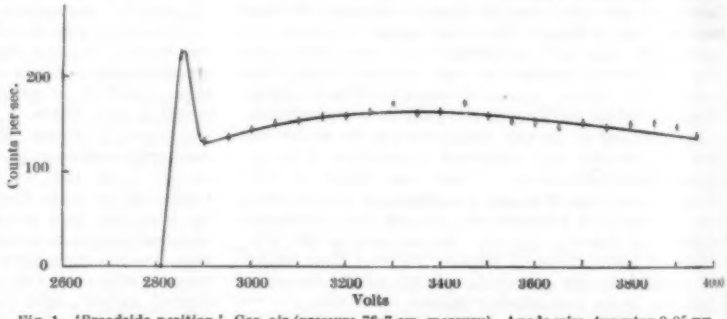

Fig. 1. 'Broadside position.' Gas, air (pressure 76·7 cm. mercury). Anode wire, tungsten 0·05 mm. diameter. Cathode wire, copper 0·9 mm. diameter. Electrode spacing 0·75 mm.

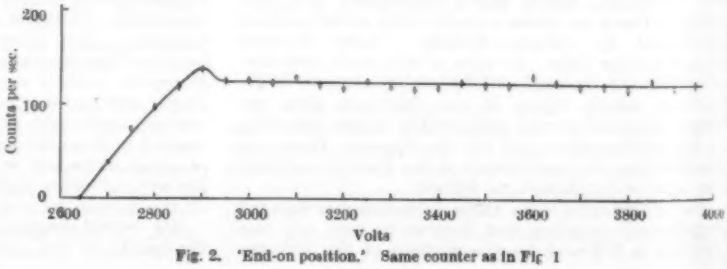

Fig. 2. 'End-on position.' Same counter as in Fig. 1

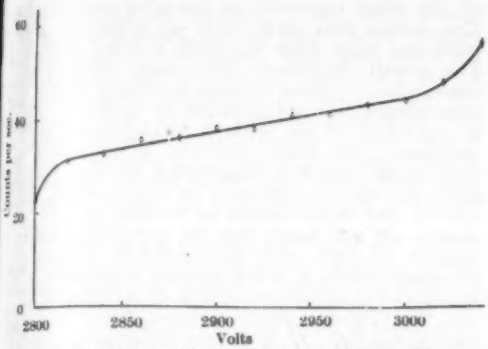

Fig. 3. 'Broadside position.' Gas, oxygen (pressure 75 cm. mercury). Anode wire, tungsten 0·05 mm. diameter. Cathode wire, copper 0·86 mm. diameter. Electrode spacing 0·625 mm.

a wire or plate cathode, two 'principal' directions, both at right angles to the axis, must be distinguished, namely, 'broadside', in which the particles pass between the electrodes and perpendicular to the plane of symmetry of the system, and 'end-on', in which the particles arrive parallel to that plane. Typical counting characteristics for these arrangements are shown herewith (Figs. 1–4), ordinates giving counting-rates and abscissæ voltages between cathode and earth.

It will be observed that the characteristics for counters operating in air are not typical of those obtained with other gases. In air, near the counting threshold and in the absence of a source, a corona spreads evenly over the anode surface, and it would seem that it is this quiescent discharge which produces comparatively large space charges in the gap, giving the air counter its long counting plateau. The corona exhibits the spectrum of molecular nitrogen in the visible and those of nitrogen and nitric oxide in the ultra-violet, much as is obtained from an air Geissler tube, with some variation in the relative band intensities.

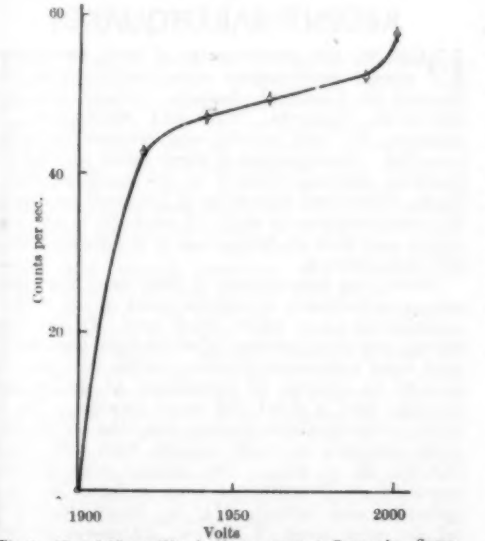

Fig. 4. 'Broadside position.' 69 cm. argon + 7 cm. air. Same counter as in Fig. 3.

No corona is visible in oxygen, carbon dioxide, argon or mixtures of these gases at pressures approximately atmospheric, and the voltage-range from threshold to continuous discharge in all cases is small, being of the order of 100 volts for gas mixtures and less for 'pure' (tank) gases. The plateaux obtained with the mixed gases are usually not more than 20–30 volts long, while a pure gas frequently fails to give any plateau at all. Using tank nitrogen alone, a beaded corona is obtained with an applied voltage of about 3 kV. Such an effect has previously been described by others[2–4] in several gases at pressures of the order of 2 cm. mercury and less. Apparently this is the first report of a beaded corona having been observed in nitrogen at atmospheric pressure, other workers having insufficiently high fields at the anode. The beaded corona at atmospheric pressure appears to possess most of the properties found at low pressures. The beading is detrimental to the proper functioning of the counter, since sparks pass preferentially to the luminous regions of the anode. No beading appears when the counter operates in air or in a wide range of nitrogen – oxygen mixtures. Tank oxygen, and nitrogen – oxygen and argon – air mixtures are generally suitable for use in the counter.

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A NEW FLUORESCENT SCREEN FOR THE ELECTRON MICROSCOPE*

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THE fluorescent screen mostly used in electron microscopes and other similar instruments is composed of the well-known willemite, of which there seems to exist a great variety, differing widely so far as grain, brightness and contrast are concerned. The main disadvantage of willemite, at least for the examination of biological material, appears to be its low brightness.

In the search for a material of greater brightness, I selected finally a screen made of zinc–cadmium sulphide (silver-activated) because of its better performance in every way. This screen, as well as a number of experimental ones, was made for me by Dr. H. Meyer[1] and Co., of Derby, to whom I wish to extend my thanks for their interest and generosity. Its characteristics are summarized in the accompanying table, giving measurements under identical conditions of beam current, etc., with the *S.E.*1 exposure photometer:

Brightness measurements of fluorescent screens (log foot-lamberts)	Willemite	Zinc–cadmium sulphide
Ordinary sample	1·7	5
Brightest obtainable	2·3	5·6

Colours of fluorescent screens matched to Ilford gelatin filters	Willemite matched to	Zinc–cadmium sulphide matched to
Characteristics of filters	407 (dark green)	401 (yellow-green)
Transmission	60 per cent	72 per cent
Wave-length	5220 A.	5500–5600 A.

* From a paper read at a conference at Cambridge arranged by the Electron Microscopy Group of the Institute of Physics on September 20–23, 1948.

The appreciation of detail in the image on the screen depends on surface structure (grain, visibility, contrast and resolution). Structures of dimensions smaller than 50 A. can easily be observed on the screen, which goes to show that the basic requirements are satisfactorily fulfilled.

The size of the zinc–cadmium sulphide crystals can be made not to exceed 1–2 μ; this is very much a matter of skill in the preparation of the screen.

Contrast, visibility and resolution depend at the present stage of electron microscopy much more on the preparation of the specimen than on the screen. By this is meant that the zinc–cadmium sulphide screen will show with good contrast any detail which is rendered visible on the photographic plate. Density measurements to assess visual contrast compared with a negative of the same field showed close agreement, though the difficulties of measuring contrast on the screen are considerable, owing to the rapid loss of contrast and the general deterioration of the specimen if it is kept for any length of time in the concentrated beam of electrons. This effect is well known, particularly as far as the 'building up' of crystals is concerned, resulting in an increase of the diameter of fine needles by several 100 per cent. This can easily be seen and photographed by exposure of, for example, zinc oxide crystals (not suspended on a collodion or other supporting film). In the case of biological specimens, a support in the form of a collodion or other film is commonly used.

It appeared from the measurements of contrast that the deterioration of the collodion film follows the same course as the thickening of the zinc oxide needles, which is in keeping with the conception of the collodion film as a closely packed crystal lattice.

One of the most important characteristics of the new screen, besides its visual resolution, is that it shows all the detail registered on the photographic plate. This means that there need no longer be guesswork and delay while the plate is being developed. The greatly facilitated observation allows speedy observation of detail without prolonged search and consequently the introduction of artefacts, owing to the effect of the electron bombardment on the specimen. This effect, however, is dependent not only on the time of bombardment, but also, perhaps more so, on the intensity, in other words, beam current and concentration or focusing by the condenser. It was found that the new screen made it possible to work with the condenser permanently defocused, which is of the greatest importance when the specimen includes structures of the order of 50 A. and the thinnest possible collodion films. For such cases it was found to be of great advantage to produce dark adaptation of at least 15 minutes previous to the actual observations and photography.

The increased visibility, of course, facilitates focusing greatly and made it possible to take photographs of structures which are quite invisible on willemite screens.

To illustrate the efficiency of the zinc–cadmium sulphide screen, four photographs are reproduced which were taken of fields that showed, on the willemite screen, none of the details recorded on the photographic plate. The electron microscope used here is the Metropolitan-Vickers *E.M.2*.

The willemite screen did not show the thickened ends of the phage tails (Fig. 1), nor the 'ingestion' or 'invasion' recorded on Fig. 2. Neither was it possible to see in Fig. 3 the extremely fine tails within the cluster of phage bodies, nor in Fig. 4 the low-brightness granules and to gain an impression of the intracellular phage bodies, as known from observations on living specimens[2].

Further work as well as technical bacteriological details will be published elsewhere.

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Fig. 1 Fig. 2

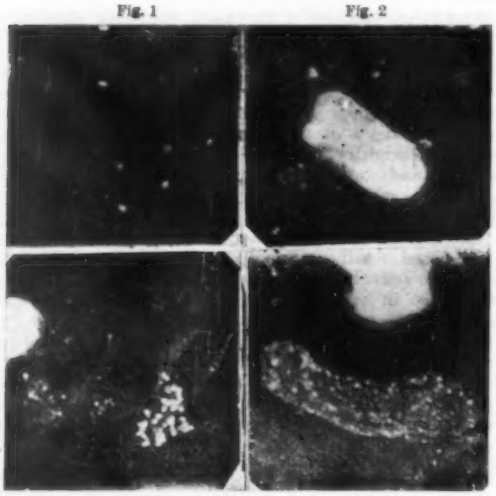

Fig. 3 Fig. 4

Fig. 1. Bacteriophage of *B. coli*; the phage bodies have tails with thickened ends

Fig. 2. A colon bacillus being 'invaded' by a phage body; its tail has been shed and it has been surrounded by the bacterial membrane. Two other phage bodies are attached to the outside of the membrane

Fig. 3. A cluster of phage bodies in an arrangement suggestive of multiplication

Fig. 4. A lysed colon bacillus in which can be seen granules of a low brightness, presumably bacillary protoplasm and a few ill-defined phage bodies. × 12,000

RECENT EARTHQUAKES

DURING the third quarter of 1948, twenty-eight strong earthquakes were registered in New Zealand at Auckland, Arapuni, Christchurch, New Plymouth, Kaimata, Tuai and Wellington. In addition, 61 local shocks and tremors have been recorded. The strongest of these latter was felt with Modified Mercalli Scale 6 in the southern part of South Island and especially at Monowai on July 14. The earthquakes of July 12 and 23 in the same region and that on September 6 at Opotiki were all felt with Scale 5.

During the last quarter of 1948 there were fifteen strong earthquakes in various parts of the world, in addition to many other minor ones. Of the fifteen strong ones the epicentres of which have been determined from instrumental observations, two were near enough to centres of population to do extensive damage, and a third did some damage. The one doing most extensive damage was that on October 5 with epicentre in north-eastern Iran (see *Nature*, October 23, p. 647). The second most damaging occurred on December 4 from a focus having an epicentre near latitude 21½° N., longitude 106½ W., off the west coast of Mexico. Extensive property-damage was done on Madre Madre Maria, the prison

island 30 miles off Mazatlan. When the two-story wireless building collapsed, the chief wireless operator and his assistant were killed. The third, which did some damage, also occurred on December 4 from a focus having an epicentre near latitude 33·9° N., longitude 116·4° W., in southern California. The strongest effects were stated locally to have been in the desert between the towns of Indio and Twenty-Nine Palms, and the shock would undoubtedly have done more damage had it occurred nearer to a centre of population.

The other strong earthquakes during the quarter had dates and epicentres as follow: October 1, near Guerrero, coast of Mexico; October 15, north of Falkland Islands; October 18, between Crete and Rhodes; October 21, off west coast of Nicaragua; October 21, near Solomon Islands; October 28, near coast of Honshu, Japan; November 1, Kamchatka; November 3, Loyalty Islands; November 19, near coast of western Costa Rica; November 21, Queen Charlotte Islands; November 26, New Guinea; December 5, south-east of New Zealand.

Of the minor shocks, an earth tremor of unknown origin was felt in Cheshire about 7.45 a.m. on October 4, one at Lyons (France) on October 20, one at Oporto (Portugal) on November 18, several in the latter half of November in the canton of Zurich (Switzerland), and others elsewhere.

None of this seismic activity can be said to have occurred in unexpected places since earthquakes have happened in the above regions previously. Seismogram readings have been received from the central stations of the Jesuit Seismological Association, United States; Strasbourg, France; United States Coast and Geodetic Survey; and individual stations at Aberdeen, Beograd, Cleveland (Ohio), De Bilt, Durham, Kew, Stuttgart, Toledo, Uccle and Zurich.

NEW BELGIAN INSTITUTE FOR SCIENTIFIC RESEARCH IN CENTRAL AFRICA

THE Institut pour la Recherche Scientifique en Afrique Centrale (I.R.S.A.C.), which was created on July 1, 1947, at Leopoldville, is a public corporation, that is to say, it is sponsored by the Government but ruled by a board of twenty-five administrators. At the beginning of 1948, the Institute was endowed with 200 million Belgian francs (£1,129,000), to be used for the erection of buildings, and another 200 million francs to be kept in Government bonds. This initial endowment will be supplemented with annual subsidies, the minimum at present being 25 million francs (£141,240).

The purpose of the Institute is the fundamental study of human, zoological and botanical environment in the tropics. Several research centres will be erected in the Congo during the next two years. The main one will probably be on the high plateau between Lake Kivu and Lake Tanganyika, south of Costermansville, where a team is now in the field, searching for a suitable site for a high-altitude astronomical observatory. This main station will house a laboratory of vulcanology, seismology and ionospheric measurements, and a department of experimental biology. Early this year a research centre devoted to hydrobiological studies will be opened at Uvira, on the northern shore of Lake Tanganyika. Another centre, for researches on physical and social anthropology, will be started, before the end of the year, at Astrida in the Ruanda, east of the Congo. A fourth station will be erected in the Province of Equator, in the low central forest, and dedicated to studies on climatology, hydrobiology, anthropology, nutrition, botany, etc.

The Belgian Congo offers unusually favourable conditions for the study of tropical environment with its wide variety of altitudes and an exceptionally good road system. The Institute will provide fellowships and subsidies to the scientific workers established in the Congo. Its aim is to co-ordinate and inspire the various scientific institutions and services there. It will have its own scientific and technical staff and will act as an information agency for men of science visiting the Congo and provide them with material help and various exploration and research facilities. Work tables will be kept at the disposal of Belgian and foreign institutions in the different centres, and a library, by far the largest one yet available in Central Africa, will be assembled at the headquarters.

The board of administrators, under the presidency of Prof. E. De Bruyne, of the University of Ghent, who was formerly Minister of Colonies in the Belgian Government, is composed of representatives of all branches of science. All of them are Belgian, except for three: Dr. E. B. Worthington, scientific adviser to the High Commissioner for East Africa in Nairobi; Dr. Harlow Shapley, director of the Harvard College Observatory; and M. A. Chevalier, professor of Colonial agriculture in the Musée Nationale d'Histoire Naturelle, Paris.

The director of the Institute, Dr. Louis van den Berghe, professor at the Institute of Tropical Medicine, Antwerp, is already established in the Belgian Congo. The present address is I.R.S.A.C., B.P. 217, Costermansville, Belgian Congo. M. J.-P. Harroy, former secretary of the Institut des Parcs Nationaux du Congo Belge, is the secretary-general of the administrative services in Brussels at 42 rue Montoyer. No scientific journal will be maintained by the Institute; but a scientific report on general subjects, including abstracts of the papers published elsewhere by the members and guests, will appear annually. A first report, for 1948, will be published by the middle of 1949.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, April 4

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (joint meeting with the LONDON AND S.E. COUNTIES SECTION of the ROYAL INSTITUTE OF CHEMISTRY, at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Dr. A. Forster: "Recent Developments in Explosives".

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON STUDENTS' SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 7 p.m.—Mr. T. Graeme N. Haldane: "Future Methods of Power Generation, and other Problems" (Presidential Address).

Tuesday, April 5

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5 p.m.—Dr. Fernando Henriques: "West Indian Family Organisation".

INSTITUTION OF ELECTRICAL ENGINEERS, RUGBY SUB-CENTRE (at the Electricity Showrooms, Rugby), at 6.30 p.m.—Mr. C. A. Cameron Brown and Mr. T. W. Golding: "The Application of Electricity to Agriculture".

MANCHESTER GEOGRAPHICAL SOCIETY (in the Geographical Hall, St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. C. A. J. Barrington: "Growing Trees".

Tuesday, April 5—Friday, April 8

PHYSICAL SOCIETY (in the Physics Department, Imperial College of Science and Technology, South Kensington, London, S.W.7).—Annual Exhibition of Scientific Instruments and Apparatus.

Wednesday, April 6

ROYAL MICROSCOPICAL SOCIETY (in the Hastings Hall, B.M.A. House, Tavistock Square, London, W.C.1), at 5 p.m. —Demonstrations and Scientific Papers.

ROYAL METEOROLOGICAL SOCIETY (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 6 p.m.—Dr. G. M. B. Dobson, F.R.S.: "Some Solar and Terrestrial Relationships".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at Gas Industry House, 1 Grosvenor Place, London, S.W.1), at 7 p.m. —Papers on the Estimation of Penicillin.

Wednesday, April 6—Friday, April 8

INSTITUTION OF NAVAL ARCHITECTS (on board the *Wellington* Headquarters Ship of the Honourable Company of Master Mariners' Temple Stairs, Victoria Embankment, London, W.C.2), at 10.15 a.m. each day. (On Friday, April 8, at 2.30 p.m., the meeting will be held jointly with the Institute of Marine Engineers.)

Thursday, April 7

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND S.E. COUNTIES SECTION (joint meeting with the LUTON SCIENTIFIC ASSOCIATION, in the Public Library Lecture Hall, Luton), at 7.30 p.m.—Dr. E. Lester Smith: "Recent Developments in Biochemical Research".

Friday, April 8

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 6 p.m.—Mr. J. H. A. Crockett and Mr. R. E. R. Hammond: "The Dynamic Principles of Machine Foundations and Ground".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. P. M. S. Blackett, F.R.S.: "Magnetic Field of Large Rotating Bodies".

Friday, April 8—Saturday, April 9

MINERALOGICAL SOCIETY, CLAY MINERALS GROUP (in the Physics Department, The University, Leeds).—Discussion on "Clay Minerals and Colloid Chemistry".

Friday, April 8

At 10 a.m.—Visits to Laboratories; at 2.30 p.m.—Scientific Session.

Saturday, April 9

At 9.30 a.m.—Scientific Session.

Saturday, April 9

INSTITUTION OF CHEMICAL ENGINEERS, NORTH-WESTERN BRANCH (at the College of Technology, Manchester), at 3 p.m.—Mr. G. B. Cox: "An Approach to the Problem of Counter-Current Fat Splitting by the Twitchell Process".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN SCIENCE, mainly Biology, at the Folkestone Training College—The County Education Officer, Springfield, Maidstone (April 9).

LECTURERS IN (*a*) MECHANICAL ENGINEERING, (*b*) ELECTRICAL ENGINEERING, (*c*) CHEMISTRY, (*d*) PHYSICS (2), (*e*) MATHEMATICS, (*f*) BOTANY/ZOOLOGY, and SENIOR ASSISTANTS IN (*a*) MECHANICAL ENGINEERING, with ability to teach management subjects, (*b*) PHYSICAL CHEMISTRY, at the Constantine Technical College—The Director of Education, Education Offices, Woodlands Road, Middlesbrough (April 9).

ELECTRONIC PHYSICISTS and ELECTRONIC ENGINEERS (Senior Scientific Officer, Scientific Officer, Experimental Officer, and Assistant Experimental Officer grades) in Ministry of Supply Research and Development Establishments mainly in Hampshire, Worcestershire and Kent—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.161/48A (April 9).

RESEARCH ASSISTANT IN APPLIED ELECTROPHYSIOLOGY in the Department of Psychological Medicine—The Registrar, King's College, Newcastle-upon-Tyne (April 9).

SUPERINTENDENT (Plans), a SUPERINTENDENT (Research and Development), a PRINCIPAL OFFICER (Optical Apparatus), a PRINCIPAL OFFICER (Range Facilities), and a RESEARCH OFFICER (Publications), in the Long Range Weapons Establishment, South Australia—The Australian Munitions Representative, Canberra House, 87 Jermyn Street, London, S.W.1 (April 11).

ASSISTANTS (3) IN THE DEPARTMENT OF CHEMISTRY, University College, Dundee (one assistant to specialize in organic chemistry, one in physical chemistry, and one in inorganic chemistry)—The Secretary, The University, St. Andrews (April 15).

INSPECTOR OF POST PRIMARY SCHOOLS, Education Department, Wellington—The Office of the High Commissioner for New Zealand, 415 Strand, London, W.C.2 (April 15).

LECTURERS (2) IN MATHEMATICS—The Registrar, King's College, Newcastle-upon-Tyne (April 16).

MATHEMATICIANS and MATHEMATICAL PHYSICISTS (Scientific Officer grade) for work in solid and fluid mechanics and high-speed gas dynamics, statistical mechanics and quantum theory, statistics, at Ministry of Supply Research and Development Establishments in and near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.392/48A (April 16).

UNIVERSITY LECTURER OR A UNIVERSITY DEMONSTRATOR IN THE ENGINEERING DEPARTMENT—The Secretary of the Appointments Committee, Engineering Laboratory, Cambridge (April 19).

LECTURER IN BOTANY, and a LECTURER IN ZOOLOGY—The Secretary, University of Durham, 38 North Bailey, Durham (April 20).

PHYSICISTS and ELECTRICAL ENGINEERS (Senior Scientific Officer and Scientific Officer grades) with experience or special interest in radio and radar research, miniaturization, VHF technique, aerial design, electronic circuit theory, electronic measurements, or digital computing mechanisms, at the Royal Aircraft Establishment, Farnborough, and other establishments in South England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.436/48A (April 20).

ASSISTANT CURATOR (male) for the Botany Department of the Natural History Museum—The Town Clerk, The Guildhall, Nottingham (April 30).

EXPERIMENTAL OFFICERS and ASSISTANT EXPERIMENTAL OFFICERS at the Atomic Energy Research Establishment, Harwell, to assist in the technical work of the Director's office and Information Service—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.60/48A (April 30).

LECTURER IN THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, The University, Edinburgh (April 30).

HEAD OF THE BIOLOGICAL SECTION of the Ministry of Labour and National Service Technical and Scientific Register—The Ministry of Labour and National Service, Appointments Department, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting G.351/48A (April 30).

MATHEMATICIANS (Senior Scientific Officer grade) for (*a*) theoretical investigation into the detonation of explosives, (*b*) numerical analysis of problems in applied mathematics, (*c*) work on fluid mechanics, at a Ministry of Supply Research and Development Establishment near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.391/48A (April 30).

DEPUTY CURATOR at the Horniman Museum, London Road, London, S.E.23—The Education Officer (EO/Estab. 2), The County Hall, Westminster Bridge, London, S.E.1 (April 30).

READERSHIP IN EXPERIMENTAL PHYSICS at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 2).

DEMONSTRATOR IN THE DEPARTMENT OF ENTOMOLOGY—The Assistant Dean, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1 (May 31).

ROYAL DUTCH SHELL STUDENTSHIP IN GEOPHYSICS—The Registrar, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7 (June 1).

SCIENTIFIC OFFICERS, EXPERIMENTAL OFFICERS, and ASSISTANT EXPERIMENTAL OFFICERS, on the research staff of the Ministry of Agriculture and Fisheries Grassland Improvement Station—The Secretary, Grassland Improvement Station, Stratford-on-Avon.

HISTOLOGICAL TECHNICIAN in the Department of Clinical Pathology—Dr. D. H. Collins, The Medical School, Leeds 2.

SENIOR TECHNICIAN (Grade A) IN THE PHYSIOLOGY DEPARTMENT—The Secretary, Marischal College, Aberdeen.

LECTURER IN THE DEPARTMENT OF BIOLOGY—The Principal, Huddersfield Technical College, Queen Street South, Huddersfield.

PLANT PATHOLOGIST in Jamaica to continue investigations already initiated into Panama disease of bananas—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

RESEARCH SCHOLARSHIPS (2) IN THE DEPARTMENT OF PHARMACOLOGY—The Head of the Department of Pharmacology, The University, Birmingham.

LECTURER IN MATHEMATICS—The Principal, West Ham Municipal College, Romford Road, Stratford, London, E.15.

SENIOR LABORATORY TECHNICIAN IN THE PATHOLOGICAL LABORATORY—The Medical Director, Marie Curie Hospital, 66 Fitzjohn's Avenue, London, N.W.3.

PHYSICIST to join a research team in Sheffield investigating rolling mill problems—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting 'Rolling Mill'.

MANAGING CHEMIST to take charge of the metallurgical development laboratories at the Ministry of Supply Springfields Factory, Salwick, Preston—The Staff Section, Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Catalogues

A Catalogue of Books and Periodicals on all branches of Zoology, Geology, Palaeontology and Botany. (No. 659.) Pp. 108. (London: Bernard Quaritch, Ltd., 1948.) 6*d*.

Industrial Plant in Glass. Pp. 58. (London: Quickfit and Quartz, Ltd., 1948.)

Sensitive, Direct-Reading Torsion Balances. Pp. 6. (London: White Electrical Instrument Co., Ltd., 1948.)

The Place Middle East Oil will occupy in World Markets. By C. J. Bauer. (Esso Publication, D.1.) Pp. 24. (London: Anglo-American Oil Co., Ltd., 1948.)

Technique. Vol. 2, No. 4, October. Pp. 25–32. (Beckenham: Muirhead and Co., Ltd., 1948.)